Managing Risks and Resilience in Supply Chain and 3PL: Conceptual Development and Proposed Frameworks

BY

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This Thesis, written by **Muhammad Akram Afzal** under the direction of his thesis advisor and approved by his thesis committee, has been presented to and accepted by the Dean of graduate studies, in partial fulfillment of the requirements for the degree of MASTERS OF SCIENCE IN SYSTEMS ENGINEERING.

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To my parents, brothers and sisters

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THESIS ABSTRACT (ENGLISH)

Name: Muhammad Akram Afzal

Title: Managing Risk and Resilience in Supply Chain & 3PL: Conceptual Developments and Proposed Frameworks

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In today's uncertain and turbulent markets, supply chain risk has become an issue of concern for business communities. Managing risk in a supply chain requires resilience – the ability to recover from or adjust easily to change or disruption. This research explores current practices in supply chain risk management (SCRM) by presenting an overview on sea of articles and describes and discusses various cases and models in practices and theory. A unique 5 dimensional framework for literature classification is constructed. Each of the dimensions in framework is further deeply explored in order to present literature overview in the best possible manner. With the help of this review, not only supply chain managers know how risks in different supply chains have been handled but academicians can also navigate through the sea of research articles. In order to fill the gap identified in aforementioned step, we provide general framework for risk management in Third party logistics (3PL) outsourcing processes. In this regard, we first provide a framework for establishing and managing 3PL relationships to understand the important elements and issues to consider in each step in order to enhance logistics outsourcing performance. Then, under the guidelines and principles of ISO 31000 Risk Management, we derive a framework for 3PL risk management that identifies various risks in different stages of logistic outsourcing process and proposes step by step approaches, tools and strategies for risk mitigation require in each phase of 3PL process. Finally, a general overview on a framework for relationship evaluation between 3PL users and providers is suggested with possible relationship attributes and tools.

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THESIS ABSTRACT (ARABIC)

CHAPTER 1

INTRODUCTION

Overview

The purpose of this chapter is to set out the background of the subject to provide general overview and to offer an outline the objectives of the thesis.

1.1 INTRODUCTION

Due to globalization and short product life cycles, competition in businesses has tremendously increased. Companies are collaborating with their business partners, suppliers and customers through supply chain network to remain competitive. In a typical supply chain network, all business partners work together so that merchandise is produced and distributed in the right quantities, to the right location and within the right time with minimized operational costs and maximized service level requirements. It is argued that by using different supply chain strategies, companies are getting competitive advantages and business efficiency (Porter, M. 1985).

No doubt about the benefits and advantages of using supply chain practices, however the risks and issues associated to them are not discussed very well in the literature (Ivan et al 2009) although the interest in supply chain risk management has been growing tremendously in the last decade. Risk is an inevitable part of our life. Risk occurs in many ways and shapes. Sometimes Risk occurs due to the element of uncertainty which is an essential part of this world. We can never know exactly what will happen tomorrow. No matter how best we forecast and do every possible analysis, but there is always uncertainty

about future events. Risk also occurs due to the environment or from our surroundings in the form of natural disasters, volcanoes, or due to political uncertainty in a country. A very recent example is the volcano that erupted in Iceland which had disrupted almost all air traffic in most European countries. BMW and Nissan suspended many of their plants operations due to supply shortages. Furthermore, FedEx cancelled more than 100 flights and almost all airlines lost an average of $200 million per day (Gill Victoria, 2010). Risk can also be internal to an organization. A possible way of risk occurrence would be when things or processes are not performing in an optimal manner such as delays in logistics operations, breakdown in manufacturing operations, or difficulties in services operations. Risks can also be external to the organization but internal to the supply chain such as problems with suppliers or difficulties in the distribution network.

Managing these risks and disruptions in supply chain is known as Supply Chain Risk Management (SCRM) and defined as "the management of supply chain risks through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity" (Tang et al. 2006).

Among many supply chain management practices, a very common one is the outsourcing of logistic activities to a third party called third party logistics (3PL). The worldwide usage of logistics outsourcing has grown dramatically over the last decades and will continue to do so. This trend is also observed in Saudi Arabia where the use of 3PL has been growing with potential for further development (Sohail et al 2005). The ability of 3PLs to play an important role in today's global supply chains will depend on their continued ability to provide value to their customers. This value arises from providing logistics services in a more cost effective manner than can be achieved by customers performing the activities themselves. Managing risk in 3PL relationships is also vital to their success.

This thesis deals with supply chain risk management in general with focus on risk management in third party logistics (3PL) relationships. More specifically, the objectives of this thesis are:

1. A general framework for SCRM based on "ISO 31000 risk management principles and guidelines" is developed through comprehensive literature review with the objective of understanding of current research development, and to have a deeper knowledge of various tools and techniques being used in identification, assessment and treatment of risks (ISO 2009). Also, gaps in SCRM literature are identified and future research opportunities are proposed. To achieve these objectives, we present an organized classification of surveyed literature. The articles are classified according to risk types, risk management process and according to different article types.

2. Then, our research objective focuses on risk management in 3PL relationships with the objectives of development of framework that would help to improve relationship between users and providers. This is achieved through the following steps. A representative literature review on 3PL outsourcing processes and relationship management is performed to determine all important aspects and elements in 3PL outsourcing processes. Based on this, conceptual framework for 3PL relationships is proposed. The derived framework is validated partially using empirical data obtained from leading organizations in the region. These data is obtained through semi-structured interviews with two leading companies in Saudi Arabia engaged in a long term 3PL relationship. The information collected and the findings of the case study help to close the gap between theoretical work and actual practices in industry.
3. Next, we examine the newly released International Standard ISO 31000 "Risk Management – Principles and Guidelines" and explore its applicability in 3PLs. To the best of our knowledge, the above mentioned framework is not implemented to 3PL context until now. A risk Management process for 3PL is proposed taking into account all the phases of 3PL outsourcing framework developed in this thesis. Various risks are identified based on the literature and through the case study conducted and methods and tools for risk identification and evaluation are

proposed as well. Also, various risk treatment strategies reactive or proactive in nature are proposed.

4. Finally, a generic model on 3PL relationship evaluation between user and provider is proposed. In this regard, important key performance indicators and metrics are identified through literature review and case study conducted. Furthermore, expected outputs impacting 3PL relationship are identified. Finally, an idea about a Neural Network that takes some metrics/ input variables and then determines the level of relationship as an output is presented.

1.2 THESIS ORGANIZATION

The Thesis is organized as follows.

Chapter 1 gives the introduction and an overview of thesis objectives.

Chapter 2 describes the approach and methodology used for achieving SCRM literature review and gap identification.

Chapter 3 gives an overview of SCRM literature that describes and discusses SCRM case studies providing a practical perspective. Over 70 case studies are considered for the analysis.

Chapter 4 reviews various quantitative models for managing supply chain risk published after 2005. More than 100 articles are considered for this purpose.

Chapter 5 reviews various conceptual articles, literature survey and papers that address complete risk management frameworks. Then a SCRM framework is proposed.

Chapter 6 provides a general framework for establishing and managing 3PL relationships that consists of four steps: i) identifying and justifying the need for outsourcing logistics activities; ii) 3PL selection; iii) contracting; and iv) relationship management.

Chapter 7 derives a framework for 3PL risk management that will not only identifies various risks that exist in different stages of the logistic outsourcing process but also proposes their respective treatment strategies along tools and methods required for each phase of the process.

Chapter 8 presents the methodology for relationship evaluation between buyer and provider through a neural network approach.

Chapter 9 presents the thesis contribution, conclusion and recommendations for future work.

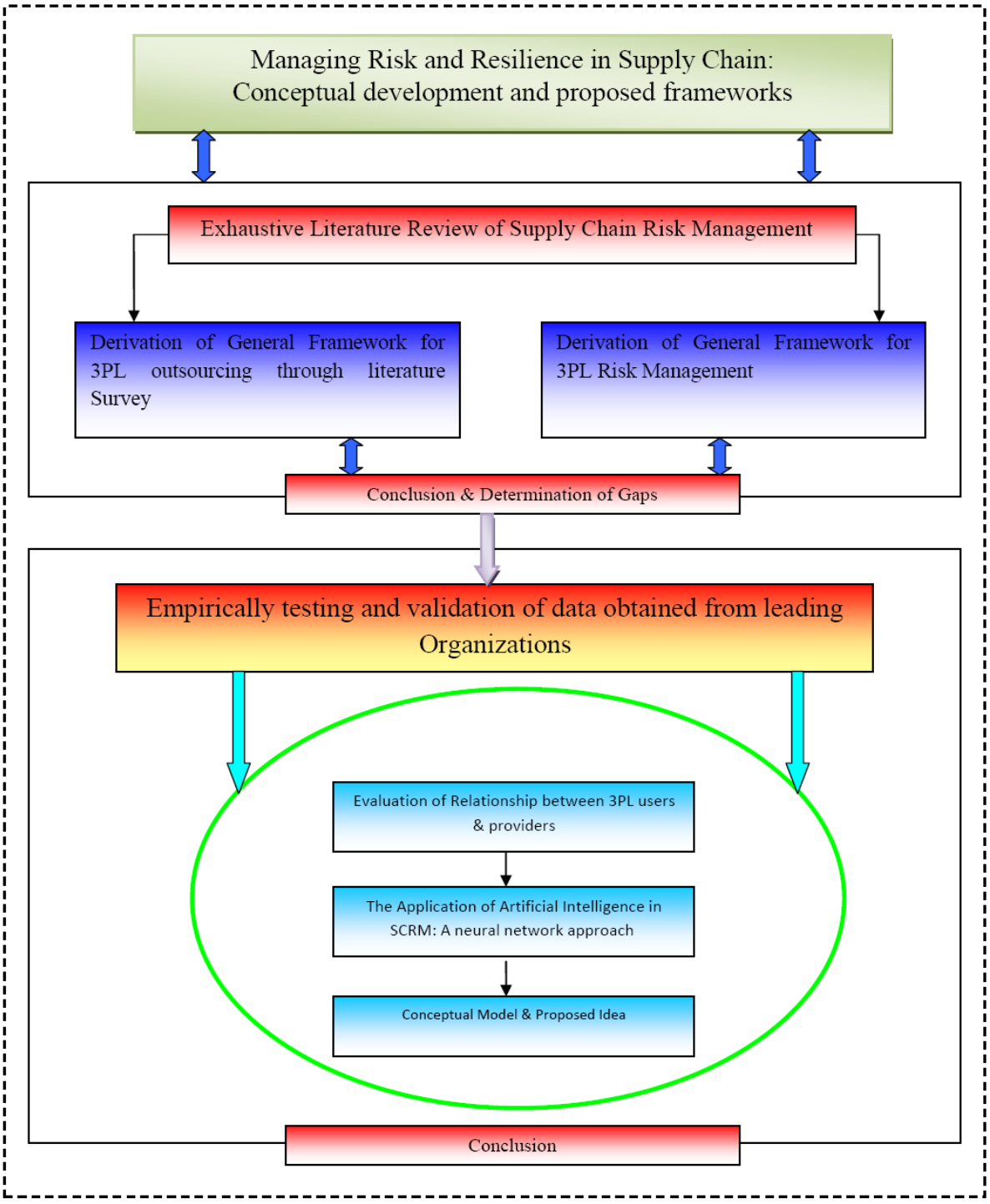


Fig1 : Thesis objectives

CHAPTER 2

SUPPLY CHAIN RISK MANAGEMENT: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

Overview

This chapter discusses different aspects of a structured framework developed for comprehensive review of SCRM literature and associated statistics facts.

2.1 INTRODUCTION

In recent years, there have been several instances of disruption in supply chain. In fact, as time passes, the element of uncertainty is steeply increasing and making supply chain more and more vulnerable. Some of them were due to natural disasters such as earthquake in Japan; volcano appeared in Iceland and flood in Pakistan. Other disruptions were due to uncertain socio economic circumstances such as in many Arab world countries, terrorist attacks in different part of worlds etc. Therefore, it is highly recommended for supply chain managers and academicians to have deep insight on past history events associated to supply chain risks, understand drivers and sources of risks in different industrial sectors, treatment strategies adopted by organizations etc and make contingency plan for their supply chain based on them.

The intent of this Chapter is twofold. Extensive review of SCRM articles according to unified framework to determine the gap in research and selection of specific future research areas require attention of academician and supply chain experts. Secondly, development of framework for SCRM based on ISO 31000 Risk Management principles and guidelines.

We present a structured framework for articles classification. The articles are classified according to risk types, risk management process and according to different article types.

2.2 CLASSIFICATION SCHEMES

2.2.1 CLASSIFICATION SCHEME 1: ARTICLE TYPES

Articles are classified according to their types, such as survey papers, case studies, modeling and simulation, Risk management process and Conceptual. A brief overview of these types is presented below.

Review Papers: articles that summarize the previous work done on SCRM generally or specifically.

Case studies: Case studies involve real industrial applications in terms of SCRM. We have further classified case studies into different sub categories.

Modeling/Simulation: Usually involve mathematical models which further classify into Deterministic analytical models such as Linear programming approach, Non linear programming or Goal programming etc, Stochastic models and simulation models.

Risk Management Process: In this category, we place all those articles that focus on complete risk management frameworks generally or specifically to supply chain issues.

Conceptual: This category consists of those articles that are conceptual or theoretical in nature

2.2.2 CLASSIFICATION SCHEME 2: ACCORDING TO ISO 31000 RISK MANAGEMENT PROCESS

Next classification is based on risk management process. We have adopted ISO 31000 risk management framework for this purpose. Important elements of ISO 31000 risk management frameworks are

Establishing the context

By establishing the context, the organization articulates its objectives, defines the external and internal parameters to be taken into account when managing risk, and sets the scope and risk criteria for the remaining process.

Risk Identification:

This step comes next to establishing the context. Risks are events that, when triggered cause problems. Hence this step can be initiated from source of the problem or within the problem. We have reviewed those techniques mentioned in articles for identification of risks.

Risk Assessment:

Once risks identified, they must be then assessed as to their potential severity of loss and the probability of occurrence. We have reviewed those techniques which help to assess the risks

Risk Treatment:

Once the process of risk assessment is finished, appropriate risk management strategies can be adopted. These strategies can be classified into two main categories, proactive strategies and reactive strategies. The Literature is full of different strategies. Some of them were classified as general. Some of them were very specific.

Monitoring and Review:

Both monitoring and review should be a planned' part of the risk management process and involve regular checking or surveillance. It can be periodic or *ad hoc.*

In this thesis, we have limited the scope of ISO framework and focus on three main aspects of risk management framework, risk identification, evaluation and treatment.

2.2.3 CLASSIFICATION SCHEME3: RISK SOURCES & MANAGEMENT

Many risk classification are already analyzed and discussed by many authors. (Tang et al 2006) categorized supply chain risks into operations and disruption risks. Another

classification is provided by (chopra and sodhi et al 2004) where author categorizes risks into delay of material from suppliers, systems breakdown and large forecast error etc. Readers are referred to table 14 in chapter 5 for more classification available in literature. We have classified risk as supply side risk, demand side risk, internal risk and environmental risk. Supply side risks arise from supplier side such as disruption of supply, inventory and schedule issues and incoming delays. Demand side risks come from downstream side of supply chain in the form of change in customer demand or forecasting error. Internal risks are refereed to organizational internal risks such as process risk, control risks etc. Environmental risk also known as external risks arise due to external factors such as catastrophic events, government regulations etc(Manuj et al 2008).

The rest of the chapter is organized as follows. We first present the methodology of research. The scholarly work done in supply chain risk management was then presented stage by stage. Finally, the report is concluded with main findings, discussion for future research and conceptual framework for SCRM. An overview of research scheme is presented in Fig 2.

2.3 APPROACH & METHODOLOGY:

We have performed comprehensive and exhaustive search of the articles related to SCRM published from 2006. There are two main reasons for not including articles prior to 2006. Firstly, the term supply chain risk is relatively new in the literature and got researcher's attention during last few years. Secondly, previously performed literature review by different researchers has already taken care of those articles published prior to 2005 very well. The literature search has been performed through various electronic databases including Science Direct, Emerald Full text, ABI/INFORMS Global Pro Quest, ISI web of Knowledge, Scopus and Inder Science. Different combinations of Key words have been used for search. Such as supply chain risk, supply chain disruptions etc. Articles not belonging to refereed journals such as conference papers, notes, books were discarded. It has been noticed from Table 1 that SCRM articles appear to be spread into wide & diversified walks of life, indicating popularity and multi disciplinary nature of the problem.

In the table, journals that published articles associated to SCRM during last 5 years are shown. Journals that have published almost 80 percent of the articles are International Journal of Physical Distribution & Logistics Management, International Journal of Production Economics, International Journal of Logistics Management, International Journal of Supply Chain Management, International Journal of Management Science and Journal of Operations Management.

2.4 RESEARCH FRAMEWORK

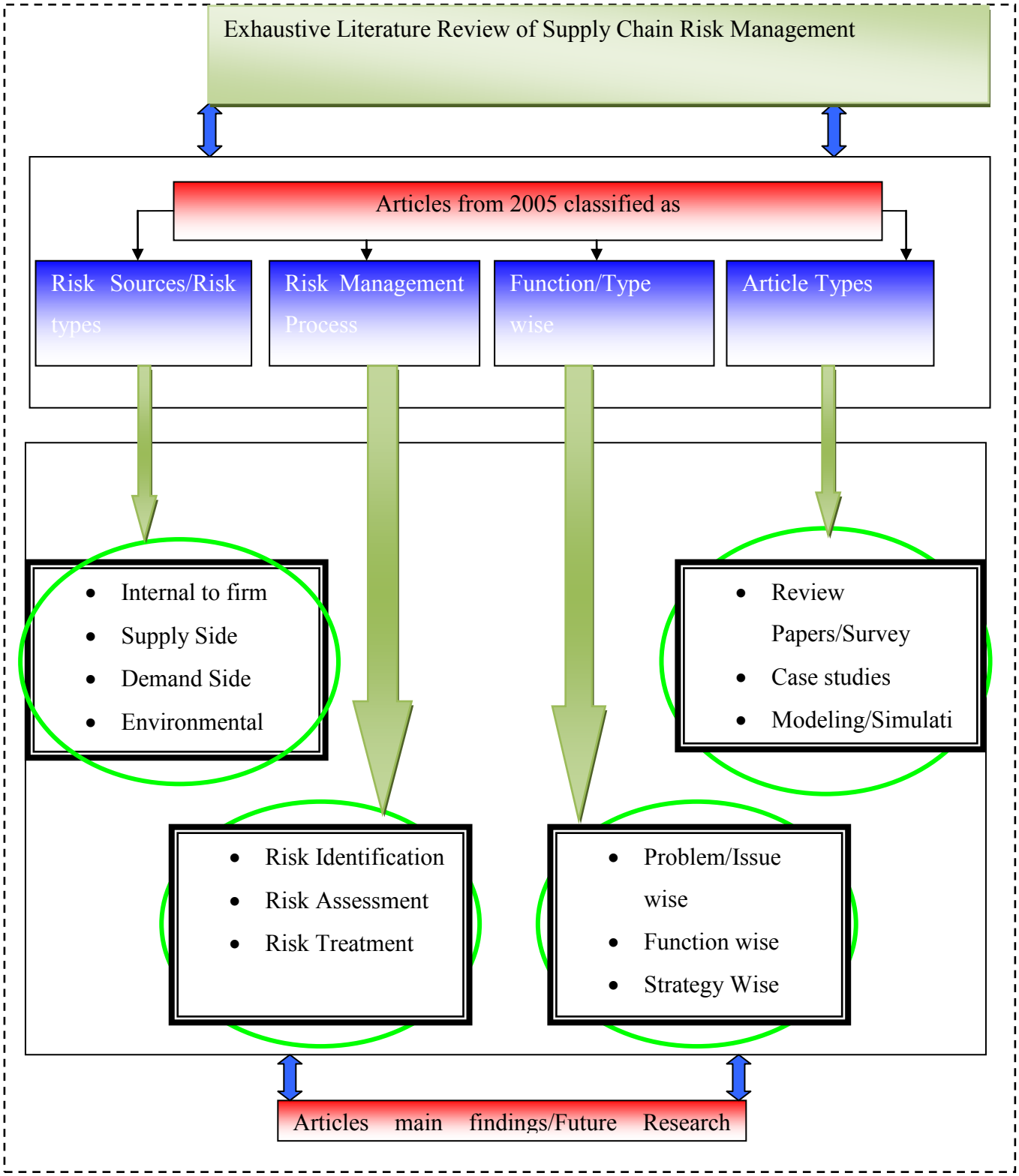


Fig 2: Research Classification Scheme

#	Journal Title	Years 2006 – 2011						
		6	7	8	9	10	11	Total
1	Acta Mathematica Scientia	1						1
2	Aiche Journal		1		2			3
3	Automatica	1						1
4	Benchmarking: An Int. J.					1		1
5	Business Process Management Journal	1			1			2
6	Chimica Oggi-Chemistry Today					1		1
7	Computer Aided Chemical Engineering			1	1			2
8	Computers & Chemical Engineering		1					1
9	Computers & Operations Research					1		1
10	Computers & Industrial Engineering			1				1
11	Computers in Industry	1			1			2
12	CrossTalk					1		1
13	Decision Sciences		2			2		4
14	Decision Support Systems			1				1
15	Environmental Science & Technology		1					1
16	European Journal of Industrial Engineering		1					1
17	European Journal of Operational Research	1	1	1	3	5		11
18	Expert Systems with Applications					3		3
19	Food Policy	1						1
20	Food Research International				1			1
21	Forest Chemicals Review				1			1
22	Fuzzy Sets and Systems					1		1
23	Human and Ecological Risk Assessment				1			1
24	IBM Journal of Research and Development					1		1
25	IEEE Transactions on Automation Science and Engineering					1		1
26	IEEE Transactions on Engineering Management			1				1
27	IEEE Transactions on Industrial Informatics				1			1
28	IEEE Transactions on Systems, Man and Cybernetics					1		1
29	IET Intelligent Transport Systems					1		1
30	Industrial and Engineering Chemistry Research					1		1
31	Industrial Engineering and Management			1				1
32	Industrial Management & Data Systems	1			2	1		4
33	Information Technology and Management					1		1

34	Information.Knowledge.Systems Management		1					1	
35	Int. J. of Agile Systems and Management			4				4	
36	Int. J. of Business and Systems Researc				1			1	
37	Int. J. of Decision Sciences, Risk and Management				1			1	
38	Int. J. of Electronic Customer Relationship Management		1					1	
39	Int. J. of Information and Decision Sciences			1				1	
40	Int. J. of Procurement Management					1		1	
41	Int. J. of Risk Assessment and Management				2	1		3	
42	Int. J. of Services and Operations Management				1	1		2	
43	Int. J. of Services Sciences						1	1	
44	Int. J. Production Economics	1	1	2	2			6	
45	Int. J. of Information Systems and Supply Chain Management					2		2	
46	Interfaces				1			1	
47	International Business Management						1	1	
48	International Business Review		1					1	
49	Int. J. of Business Information Systems					1		1	
50	Int. J.of Electronic Marketing and Retailing						1	1	
51	Int. J. of Hydrogen Energy						1	1	
52	Int. J. of Innovative Computing Information and Control					1		1	
53	Int. J. of Integrated Supply Management				1			1	
54	Int. J. of Logistics Economics and Globalisation				1			1	
55	Int. J. of Logistics Management	1	1	2	3	1		8	
56	Int. J. of Logistics Management Decision		1					1	
57	Int. J. of Logistics Research and Applications	2				2		4	
58	Int. J. of Management and Enterprise Development		1					1	
59	Int. J. of Operational Research					1		1	
60	Int. J. of Operations & Production Management		1	1	1			3	
61	Int. J. of Physical Distribution & Logistics Management			4	9	1		14	
62	Int. J. of Production Economics	1	2	2	3	4	1	13	
63	Int. J. of Production Research		1	1		4	1	7	
64	Int. J. of Risk Assessment and Management		1	2				3	
65	Int. J. of Systems Science					1		1	
66	Int. J. of Technology, Policy and Management			1				1	
67	Journal of Business and Industrial Marketing					1		1	
68	Journal of Business Logistics	1		2	2	1		6	

69	Journal of Enterprise Information Management		1	1				2
70	Journal of Environmental Management					1		1
71	Journal of Global Business Issues			1				1
72	Journal of International Business Studies					1		1
73	Journal of Internet Commerce	1						1
74	Journal of Korea Trade		1					1
75	Journal of Management Information Systems			1				1
76	Journal of Manufacturing Technology Management	1			1	1		3
77	Journal of Marketing Channels				2	1		3
78	Journal of Modelling in Management					1		1
79	The Journal of Operational Risk				1			1
80	Journal of Operations Management	1			5	1		7
81	Journal of Pharmaceutical Innovation				1			1
82	Journal of Professional Issues in Engineering Education and Practice			1				1
83	Journal of Purchasing & Supply Management	1		1		2		4
84	Journal of Research and Practice in Information Technology					1		1
85	Journal of Service Science and Management			1				1
86	Journal of Southeast University		1					1
87	Journal of Supply Chain Management					3		3
88	Journal of Systems Engineering and Electronics	1						1
89	Journal of Systems Science and Systems Engineering		1					1
90	Journal of the Operational Research Society		3	2				5
91	Journal of Transportation Security					1		1
92	Control and Decision					1		1
93	Kybernetes					1		1
94	M&Som-Manufacturing & Service Operations Management		1					1
95	Management Research News			1	1			2
96	Management Science				1	1		2
97	Manufacturing and Service Operations Management					1		1
98	McKinsey Quarterly		1					1
99	Naval Research Logistics	2	1		2			5
100	Omega- Int. J. of Management Science		2		3	1	2	8
101	Operations Management Research				1	1		2
102	Process Safety and Environmental Protection					1		1

103	Production and Operations Management				1			1
104	Production Engineering			1				1
105	Production Planning & Control	2			1	3		6
106	Quality Progress			1				1
107	Review of Business			1				1
108	Anforderungen und Umsetzungsstand					1		1
109	Risk Analysis				1	1		2
110	Risks Management Science	1						1
111	Safety Science					1		1
112	SCMS Journal of Indian Management				1			1
113	Strategic Outsourcing: An Int. J.			1				1
114	Studies in Computational Intelligence	1						1
115	Supply Chain Management Review	1	1	1				3
116	Supply Chain Management: An Int. J.	1		2	2	1	2	8
117	Supply Chain Manufacturing and Logistics	1						1
118	Systems Engineering					1		1
119	Technological and Economic Development of Economy			1				1
120	Thunderbird International Business Review					1		1
121	Toxicology	1						1
122	Transportation Journal			1	1			2
123	Transportation Research Part B: Methodological					1	1	2
124	Transportation Research Part E		1					1
125	WSEAS Transactions on Systems	1				2		3

Table 1: Journal wise statistics

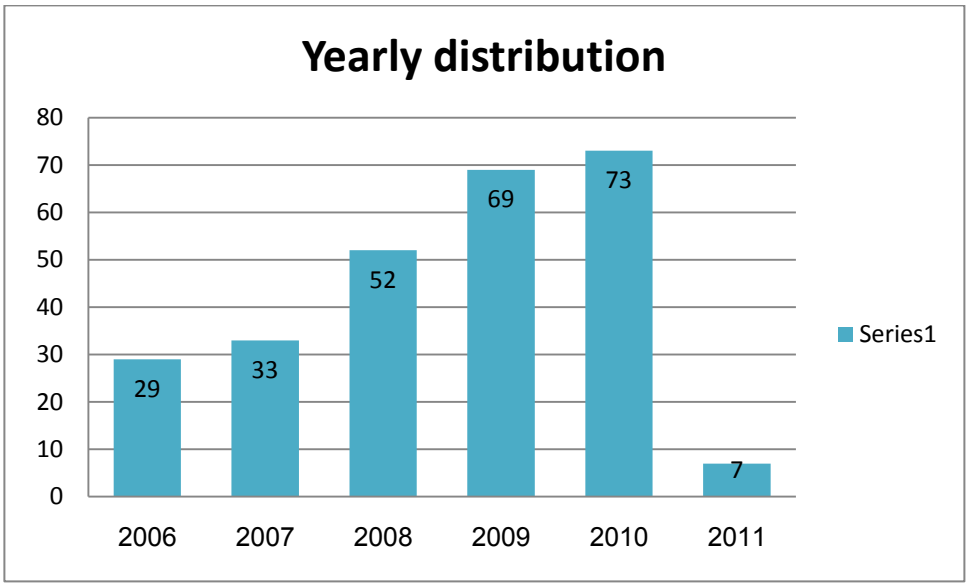


Fig 3: yearly distribution of articles

Figure 2 shows the yearly distribution of articles during last five years. Clearly, we can see a steep increase in the number of articles. The distribution is also suggesting that SCRM articles would be more in the future.

In coming three chapters, the literature review is performed categorically as per classification schemes proposed. Chapter 3 discusses case studies from different industrial sectors with the objective of understanding of risks associated to these sectors, and all relevant aspects of risk management process perform by academicians or industrialists such as tools/approaches and strategies. The similar research methodology is implemented to quantitative models whether mathematical, statistical or others and presented in chapter 4 with main findings and conclusions. Finally, survey articles, risk management frameworks and conceptual papers are presented in chapter 5 along a derived framework based on thorough literature review.

CHAPTER 3

IDENTIFICATION OF RM PROCESSES AND RESEARCH ADVANCEMENT IN SCRM: AN INDUSTRIAL PERSPECTIVE

Overview

This chapter gives an overview of SCRM literature that describes and discusses case of supply chain management with risk considerations in practices. Over 70 case studies are considered for the analysis. Based on these case studies, we are able to indicate critical risk factors exist in different industrial sectors. Furthermore, the treatment strategies used for mitigation are also summarized. Finally, various future research opportunities are provided.

3.1 INTRODUCTION

Industrial case studies have always been an essential source of understanding problems and issues today' businesses facing. Without complete and thorough understanding of these issues, academic research would be of no use. It is always crucial for industries to recognize supply chain risks and threats rising in the current turbulent era.

According to the analysis performed, more than 300 journal articles have been published since year 2005 only. This chapter gives an overview of SCRM literature that describes and discusses case studies of supply chain management with risk considerations in practices. Over 76 case studies are considered for the analysis.

Based on these case studies, the following important objectives are achieved.

- Identification of various industrial sectors with SCRM applications
- Identifications of risks and threats currently facing industries.
- Approaches and treatment strategies adopted by industrial experts or proposed by academicians.
- Finally, a comprehensive review of SCRM articles according to a structured framework is presented in order to determine the gap in research and avenues of future research areas.

The rest of the chapter is organized as follows. We first present the research methodology. The scholarly work done in supply chain risk management was then presented stage by stage. Finally, the chapter is concluded with main findings, discussion for future research and conceptual framework for SCRM.

3.2 APPROACH & METHODOLOGY

We have performed comprehensive and exhaustive search of the articles related to SCRM published from 2005. There are two main reasons for not including articles prior to 2006. Firstly, the term supply chain risk is relatively new in the literature and got researcher's attention during the last few decades. Secondly, previously performed literature review by different researchers has already taken care of those articles published prior to 2005 very well. The literature search has been performed through various electronic databases including Science Direct, Emerald Full text, ABI/INFORMS Global Pro Quest, ISI web of Knowledge, Scopus and Inder Science. Different combinations of key words have been used for search. Such as supply chain risk, supply chain disruptions etc. Articles not belonging to refereed journals such as conference papers, notes, books were discarded.

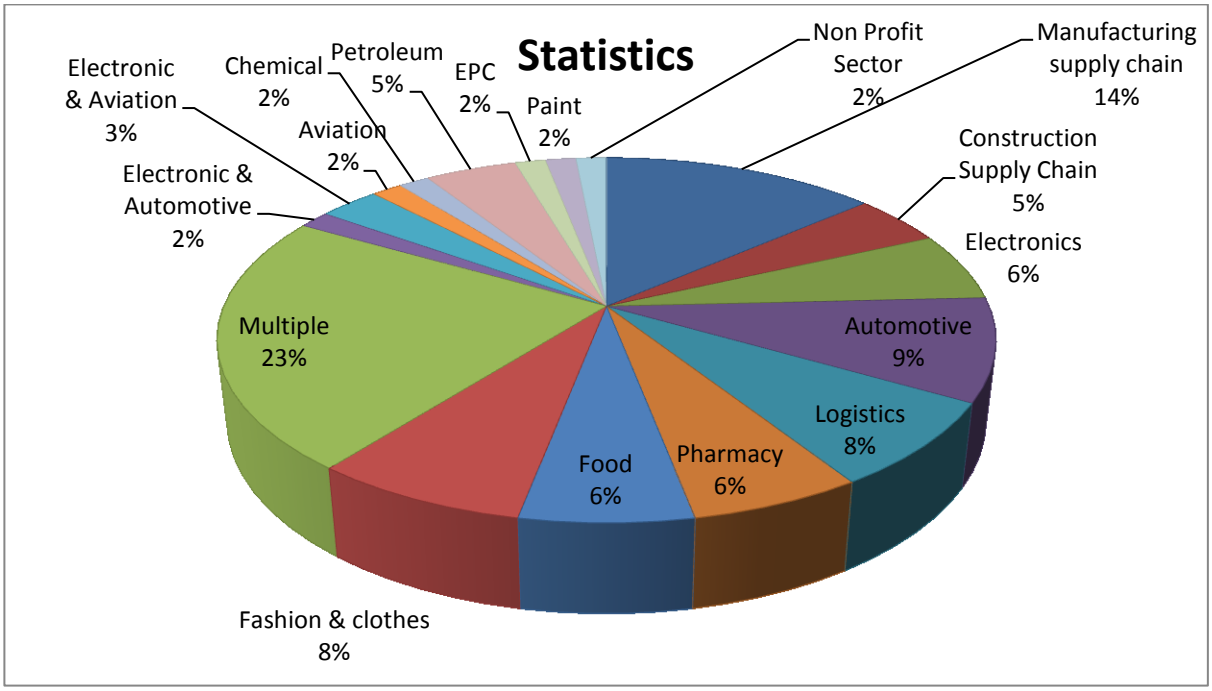


Fig 4: Sector Wise Statistics

3.3 DISCUSSION AND ANALYSIS

There is voluminous amount of published works that focus on empirical analysis for determination of various risks in supply chain under different environment, industries and stages and their mitigation strategies. The articles appeared to be spread in many different industrial sectors. Due to that fact, this section was further divided into different classifications based on different industrial sectors, such as manufacturing, Construction, Electronic, automotive, logistics, pharmaceutical sector, food, fashion, multiple sectors and other such as EPC, petroleum.

3.3.1 MANUFACTURING SECTOR

Not much article found on manufacturing industries in the SCRM issues. Supply chain management has been modeled by researchers both mathematically and with the help of simulation approach. Many studies are available in the literature that has used different

simulation approaches to simulate supply chain network. Petri nets are one of approaches used for designing discrete event dynamics systems. Previously performed studies on Petri nets approach have not been considered risks and uncertainties in simulation, However, (G.Tuncel et al 2009) modeled a Supply chain network of a manufacturing company and two immediate supply chain partners, i.e. retailer and customer with risk considerations . Author has identified risks exist at different supply chain level by conducting case study using FMEA approach. Authors further used a timed Petri nets framework to analyze the supply chain operational strategies subject to various risks. Based on these simulated results, author concluded Petri net approach not only be used for risk modeling and analysis but can be used for designing, analyzing, specification and evaluation of a supply chain.

Due to anticipated change in business environments, firms are assessing their current off shoring strategies and recognizing the strategic importance of decisions associated with off shoring process.

(Tobias et al 2008) assessed various risks associated to off shoring process through case study approach in a large US manufacturing firm and proposed a methodology with the integration of action research & analytical hierarchy process techniques. With the help of proposed methodology, author discussed various strategic aspects, such as how outsourcing decision should be made, what are risk sources involved in it and how AHP used to make outsourcing decisions.

To gain cost advantage and cheap labor force, many manufacturing firms outsource their function to low labor cost countries. However, risks associated to such countries such as low quality, late deliveries etc get increase. To reduce the effects of these risks and disruptions, (X.Li&I.Barnes et al 2008) performed analysis to identify supply risk management approaches when sourcing from such emerging market. With the help of case study approach, author concluded that supply risks must be identified and risk management strategies should be adopted to minimize supply risks. The proposed proactive risk management strategies are conduction of supplier questionnaire covering a wide range of business dimensions of the supplier; performing a technical review; negotiating a risk

mitigation plan; employing local based procurement staff; using a total cost estimate; applying a strict part qualification process.

Supplier selection is another important step for manufacturing firms to tackle with. The literature is full of those articles those mentioned various characteristics need to be considered during supplier selection. However, (R R.Levary et al 2008) emphasized that risk of disruption to manufacturer's operations must be considered with other important selection characteristics. Through a case study conducted in a manufacturing firm, the author showed that how AHP technique can be used for the selection of suppliers. Risk factor was included in term of reliability of supplier with various other characteristics. AHP model was used for final selection of suppliers.

(Ritchie et al 2007b) presented a framework for SCRM and than implemented to manufacturing industry for empirical case example. The different stages of framework are risk context and drivers, risk Management influencers, decision Makers , risk Management, responses, and performance outcomes .The different sources of risks are external environmental, industry specific, Supply chain configuration, partner specific and node specific. Risk management influencers stage is specifically analyzed by authors and consists of reward, risk, timescale and portfolio. In decision maker stage, important factors defined by the author are perceptions, risk profile, attitude and experience. In the risk management response, the types of strategies are risk taking, avoidance, mitigation and monitoring. Three classifications are profit related, strategic positioning and personal defined by author in performance outcomes.

Supply risk management is widely discussed in the literature; however, in a small company context not much research is done. (Chris Ellegaard et al 2008) tried to fill the gap by interviewing various small manufacturing's companies' executives to determine their supply risk management approaches. Author concluded that owners of small companies are using those supply risk management approaches that are defensive in nature. Some of the strategies used by these manufacturing companies for risk eliminations are knowledge protection and local sourcing, for relationship development, practices such as fairness and loyalty are being used. These executives usually prefer responsiveness, dependable and like minded suppliers.

We can make following conclusions from this section. Two articles are focusing on supply risk management issue only. Which enable us to conclude that almost all manufacturing firms has realized the importance of risks raise from upstream in the supply chain and taking preventing strategies to protect them. It has been found that risk related downstream supply chain is neglected by scholars such as demand side risks, quality risks etc.
(Lee, R. P. et al 2010) investigated various types of risks in New Products Alliance. These risks are performance risks, relational risks and knowledge appropriate risks. Furthermore, author also examined how the two governance mechanisms (explicit contractual and normative governance) are used for new product alliances success. The author use the latent class regression analysis to explore the role of heterogeneous intra- and interfirm factors that may play out in risk management and NPA success.

3.3.3 CONSTRUCTION SECTOR

Another important industry sectors where not much work has been done yet is the construction supply chain. (Achard, P. O 2008) discussed risk identification stage in the supply chain of infrastructure construction project . The author proposed also a way to identify risk within construction sectors and further explored crucial issues regarding risk identification stages. The main classification of the article is categorize as strategic objectives; critical success factors; environment and stakeholder influences; key performance indicators and principal risks; principal risk response strategies. (A.S. Oyegoke et al 2008) argued that how agility in supply chain can be achieved through the inclusion of risk management in the supply chain. Author further identified those areas that prone to greater risks and uncertainties and created agility gap in construction projects. To achieve agility, author concluded the articles by recommending various strategies. I.e the involvement of the agile specialists that will not only mitigate risks and uncertainty, but also enhances the project quality and permits a modular approach to design that permits the use of experts' knowledge in design and construction. An ideal supply chain is one where there is complete agreement and common perceptions of risk distribution patterns between all stakeholders. With that practice, risks of potential for disagreement, dispute and conflict

during the course of a project can be minimized. (M. Loosemore et al 2008) explored the difference between perception of risks in construction projects between various players. Authors have not only identified various internal and external risks exist in construction projects but also proposed a way to have common perceptions of risks in the projects. Finally, Authors indicated that the key to better managing perceptions of risk is fundamentally one of communication, consultation and involvement in contractual decision-making.

Main findings are Common perception of risks is necessary between all stakeholders within supply chain. Effective communication, consultation and involvement in contractual decision making are ways to achieve common perception. Risk management process has to be included to have an agile supply chain. Involvement of agile specialist in construction project is necessary to achieve agility in construction projects. Design of any system or product plays an important role in classifying the products or systems as more or less risky. Firms can achieve competitive advantage by designing innovative products. One approach for designing such product is product alliance with business partners. Although new product alliances create value for firms, they are also risky.

Table 2: : summary of Manufacturing sector

Sector	Author	Issue tackle with	Risks identified	Proposed solution/RM Strategy
Manufacturing Sector	G.Tuncel et al 2009	Risk modeling, designing, analyzing and evaluating supply chain from manufacturer's perspective	Supplier, inbound /outbound logistics, manufacturer and customer	Petri net approach simulation
	Lee, R. P. et al 2010	Risks associated to new product alliance	Performance risk, relational risk, knowledge appropriation risk	explicit contractual and normative governance approaches
	Ritchie et al(2007b)	How to deal challenges posed by changing supply chain context	Environmental characteristic, Industry characteristic, Organization's strategy ,Problem specific decision making unit, supply chain configuration and supply chain members	Constructed a framework for supply chain risk management
	Tobias et al (2008)	Outsourcing decision Risk sources	Product related, Partner related and environmental	Integration of AHP and Action research method
	X.Li&I.Barnes et al(2008)	Supply risk management	Supplier risk from emerging market [Limited technical capability, Over capacity, Lack of customer support, poor supply chain management, Lower level of integrity of agreements, Poor control and management of their sub-suppliers' performance, Poor logistic control of sub-suppliers, Lack of customer support, Limited technical capability, Insufficient capacity (over capacity), Lack of customer support, Lack of standard quality assurance, Poor logistic control of sub-suppliers, Longer supply chain than expected, Slow reaction to issues, Poor stock management, Large fluctuation in material costs]	conduction of supplier questionnaire covering a wide range of business dimensions of the supplier; performing a technical review; negotiating a risk mitigation plan; employing local based procurement staff; using a total cost estimate; applying a strict part qualification process
	R R.Levary et al(2008)	Risk consideration in Supplier selection	Country risk such as political situation of country, natural or manmade caused disasters and currency convertibility risks	AHP
	Chris Ellegaard et al(2008)	Supply risk management in small companies perspectives	Supply side risks, risks in supplier selection	knowledge protection and local sourcing, fairness and loyalty, responsiveness, dependable and like minded suppliers.
	Illa manuj et al(2008-b)	Exploration of the phenomena of risk management and treatment strategies	Supply risks, demand risks, opertional risks, security risks, macro risks, policy risks, Competitive risks and resource risks	Provide six risk management strategies and role of 3 moderator s
	Omera khan et al(2009)	Investigation of interface between product design and Supply chain	Risks in innovative product design, Lack of collaboration, lack o integration	Design led products, 4c approach for transformation of traditional structure to design centric structure, champion for product range, cross functional team, cooperation in the extended enterprise and co-location of concurrent design teams

3.3.4 ELECTRONICS SECTOR

Electronic industry is more prone to risks and uncertainties as compare to any other due to the fact that products have short life cycle and uncertain demand, Such as mobile phones, MP3 players and computer accessories etc. (Sodhi et al 2005).

Various risk management strategies have been used by firms for supplier risk mitigation. However, trade off analysis need to be made for strategy selection. (Manoj, U. V.2009) evaluated two sourcing policies to mitigate supply disruption due to external and political risks when sourcing from other countries. Such as delay in port etc and other political risks. The author tried to make tradeoff between risk inventory cost and expected loss of business due to disruptions. Author further demonstrated how payment contract can affect the sourcing policy. Many supply chain risks such as demand side risks of product, cost risks and product unavailability risks have significant impact on a firm's revenue and profit. Due to them, Companies binding in fixed price contracts with the suppliers either have to pay more than their competitors or have to stock extra inventory. To handle such risks and issues, procurement risk management group at HP has developed a mathematical model, process and software. (Nagali et al 2008) highlighted the significance of a this tool and mentioned that due to that software HP has realized more than 425 million cumulative cost savings during last year's. Some of the key innovations of this approach are development of scenario based approach to quantify uncertainties related to cost, demand and other aspects. Development of risk sharing portfolio of structured contracts to manage risks associated to contracts and finally development of cross functional business processes involving planning, procurement and finance to management supply chain risks. Successful management of risks always starts with complete understanding of all threats and risks associated to supply chain. (MS Sodhi et al 2007) studied and listed various risks associated to supply chain specifically to electronic consumer industry. The main classification of risks are supply related risks, demand related risks and contextual risks. Each of these risks was further classified into many sub categories. The author enlisted those strategies used by Samsung for mitigation purposes. Author further emphasized on the fact that managing the risks is a complex task. Mitigating one risk may increase the exposure of other risks or can impact other factors in firms. Therefore, it is always recommended to make a supply chain more responsive rather than efficient due to the fact that lean inventory (efficient supply chain) may take to huge loss

if supply disruption occurs. Furthermore, Firms can also mitigate risks by building various forms of reserves including inventory, capacity, redundant suppliers and responsiveness. Among many types and strategies used in supply chain, Make to order and Make to forecast are of significance importance used by firms according to their product types and market situations. However, an important aspect of these strategies is their performance during supply chain disruptions. (I.S.Papadakis et al 2006) tried to identify the difference between the financial performance of those companies having pull type and push type designs after exposing to serious supply chain disruptions. Author concluded that there is strong evidence between companies supply chain strategy and risk structure. For example, MTO supply chain when expose to disruptions reveals low profitability as compare to MTF supply chain.

Main finding are Identification of risks in electronic industry, RM tools and software for handling issues Effect of disruptions on supply chain types

Table 3: Summary of Construction & Electronics Sectors

Construction Sector	A.S. Oyegoke et al(2008)	Examine the agility gap comes from various risks in construction projects	Supplier side, Internal, Stakeholder	Introducing agility in SCRM through the concept of integration and fragmentation in product development and execution , involvement of the agile specialists
	Achard, P. O.(2008)	Identifications of risks in Construction infrastructure	Environmental , Stakeholder and principal risk	
	M. Loosemore et al(2008)	Perception of contractual risk allocation in construction supply chain	Risks in construction supply chain [imbalances of abuses and power, poor risk management practices, complexity of contracts and risks, changing procurement methods, conflicting advice, organizational dynamics, cost and time pressure, unclear project goals, defensive routine, poor risk communications	communication, consultation and involvement in contractual decision-making
Electronics & Telecommunication Sector	Nagali, V.et al(2008)	demand side risks of product, cost risks and product unavailability risks	Technical challenges in managing procurement uncertainties, Business processes challenges, cultural challenges	Development of scenario based approach to quantify uncertainties related to cost, demand and other aspects. Development of risk sharing portfolio of structured contracts to manage risks associated to contracts and finally development of cross functional business processes involving planning, procurement and finance to management supply chain risks.
	Manoj, U. V.(2009)	Examination of sensitivity of different sourcing policies	Supply risk,[impact on supply due Disruption risk]	Payment contracts types Vs Sourcing plan
	MS Sodhi(2007)	Managing all types of risks associated to electronic industry	Supply related risk [Mergers-and-acquisitions threat, 'Acts of God', war, terrorism, sanctions Political risk , Capacity risk , Single sourcing , Intellectual property risk , Supplier delays, Inventory risk, Demand side related risk [Possibility of worldwide recession , Reputation risk , Technology change risk , Change in customer preferences Forecast risk Receivables risk] *Contextual risks,* Environmental risk and compliance, Regulation compliance , Exchange rates , Financial risk , Systems risk , Cultural differences ,	Design responsive supply chain building various forms of reserves including inventory, capacity, redundant suppliers and responsiveness Make to order and Make to forecast
	I.S.Papadakis et al(2006)	Financial implication of SC design exposing to disastor	Environmental risk earthquake	MTO supply chain when expose to disruptions reveals low profitability as compare to MTF supply chain.

3.3.5 AUTOMOTIVE SECTOR

Automotive sector is another industrial sector addresses a lot by scholars. (Berry, A 2007) examined performance and relationship risks in automotive supply chain through two case studies of Tier 1 suppliers.

Financial default or bankruptcy of supplier is a major risk growing now days. To protect them from supply disruptions, firms are usually safeguarding by installing redundancy in backup supply. Multi supplier strategy is most used strategy by firms (Tang et al 2006) against supplier default risks. However, (S.M. Wagner et al 2009-b) conducted analysis on this scenarios and argued about supplier default dependencies. Author stated that in most cases firms are not operating in isolation and their financial situation is mostly interlinked with each other. Due to that there is high likelihood of default dependencies with each other. For example, in case of catastrophic event in a country and firm's original and backup supplier both located in the same country. In this case both suppliers will potentially be defaulted. Author performed different simulation scenarios with the help of copula function, a method used in finance related problems a lot. Based on these simulations, authors proposed various suggestions that need to be consider when making outsourcing decisions. A very powerful strategy is supplier development with relationship specific investment and upgrade supplier's performance or development of supplier from supply base and in case of disruption switch to that supplier. In case of multiple sourcing strategies, creation of a backup supply base of independent suppliers such as located at different parts of worlds etc.

(Canbolat, Y. B. et al 2008) also analyzed supply risk management by gathering various risk factors through case study approach. The author used FMEA and simulation tools for risk characterizations and calculations. The model not only present a management tool to mitigate supplier's risks but also help to select less risky suppliers from potential lists.

Auto companies usually outsource their various spare parts manufacturing to different suppliers from all over the world. In this way, most companies usually dependent upon various suppliers. There is need of practical methodology that not only provide early warning system to a company about their risky parts and suppliers but should have a visual reporting mechanism. Jennifer 2008 et al developed such a methodology for parts & suppliers of major auto manufacturer. The author first identified risk factors associated to auto manufactures and applicable for generalize industry as well. With the help of Multi criteria scoring procedure, author showed that how risks are characterized and evaluated. With the help of methodology,

risk assessment for different spare parts of auto cannot only be made but supply base can also be assessed. The methodology takes as an input raw data and converts it into various forms of decision support for issues such as supply base, parts availability, decision for contract renewal etc. different steps of methodology are identification of risk factors along with their weights, risk assessment with the help of multi criteria scoring procedure, supplier risk assessment calculations, critical part and supplier analysis and predictive risk analysis.

(P.Trkman et al 2009) presented a new way of classification of risks arising from turbulent environment. Authors divided the risk sources into two main categories known as Exogenous and endogenous uncertainties. Exogenous uncertainties are those that appear from outside the supply chain such as catastrophic events, political risks etc. On the other hand, endogenous risks appear from inside the supply chain and are network related. i.e. relationship between firm and other partners. Author further divide endogenous uncertainty into market and technological turbulence. Market turbulence are those turbulences arises from heterogeneity of market and results in change in customer preferences while technological turbulences are refers to degree to which technology changes over time in industry, process or in product. Exogenous uncertainty further divides into continuous and discrete risks. Continuous risks refers to those where the cost of potential changes are continuous such as loss in market share etc and discrete risks refers to low likelihood and high impacts events such as catastrophic events. Endogenous uncertainty can be mitigated by with many strategies such as closer relationship with suppliers etc. However strategies for exogenous risks are reactive in nature. The authors present a conceptual framework based on contingency theory for assessment and classification of suppliers with consideration of characteristics, performance and environment. Both the environment of supplier and company's selection strategy is considered during estimation of supplier non performance. An important aspect of the methodology is supplier performance and uncertainty matrix where supplier performance in chain and turbulence of environment is considered to determine supplier position.

A very fundamental aspect in the academic research is to know about the status quo of SCRM practices in different region worldwide. (J.-H. Thun et al 2009) analyzed the SCRM practices in German automotive industry by formulating various hypotheses and validated them empirically. Author concluded that supply chains are predominantly vulnerable to risks due to two main factors, Complexity such as globalization and product variants and efficiency such as outsourcing or reduction of suppliers. Author further classified risks sources as internal and external to supply chain. Study reveals that internal risks are regarded as being more likely to occur compare to external risks and would have more impact too.

Author further reveals that firms those have low implementation of risk management program are more prone to risks and have lower average value all investigated performance criteria such as resilience against disruptions, reactivity and flexibility improvements. In terms of strategies used by firms, two important findings are, reactive instruments are less implemented compared to preventive instruments due to the fact that they are cost intensive and firms using preventive instruments are more resilient than reactive. However, reactive supply chain management is more effective in terms of external impacts.

3.3.6 LOGISTICS AND TRANSPORTATION SECTOR

Many different concepts and approaches are being used for managing risks in supply network, such as BCP. The concept of Business Continuity Planning is discussed by (Ojha et al2009) who developed Logistical business continuity planning scales and evaluated them with the help of survey to 106 firms in logistics and transportation. According to author, LBCP is an interdisciplinary approach for the creation of logistic plan that will assist firms to recover back after a disaster or disruption. LBCP can be divided into three main stages, identification stage where risk sources are identified with the help of different approaches, management stage is to react once incident occurs or to remedy the potential threat and learning stage uses for knowledge management and learning from failures .Cargo transport process has significance importance in Logistic and transportation. However, this sector is also exposed to risks as other areas of supply chain get expose. Cargo theft appears to be major risk in this sector and it was estimated that theft represents 10 billion dollars loss per year in USA. (D. Ekwall et al 2009) analyzed those reasons due to them, the cargo theft is continuously happening whole over the world. The author proposed hypothesis based on different scientific studies such as criminology and verified their validity through interviews and surveys. Author concluded that theft risk arise from those opportunities that always present in transport network. Another important analysis was performed by (Kumar, S 2008) who tried to identify what are the major problems for cargo container shipments and what impact could a standardized security approach have on it. The author has used the concept of Six Sigma for this purpose and showed step by step analysis of his study and provided various managerial recommendations. In recommendations, author divided security measures into physical security, information security and freight security. Each of these aspects

contains basic initiatives and advance initiatives. Author suggested that at least basic security measure must be implemented to mitigate such risks.

(V.S.Rodrigues et al 2010) highlighted various risks associated to transport operations in UK supply chain. Author indicated that main sources of risk resulted in the reduction of efficiency of transportation system are delays, variable demand/poor information, delivery constraints and insufficient supply chain integration. Logistic activities are being outsourced by firms to 3PLs to gain competitive advantages and to reduce cost. However, it does not always achieve the expectation of firms due to risks associated to 3PL's logistics. (Tsai, M. C et al 2008) developed a qualitative risk model to empirically identify the important outsourcing risks of logistical functions using the data of Taiwanese retail chains. The author combined Transaction cost theory (TCT) and resourced based view (RBV) to develop risk events. Three main risks are asset risks, competence risks and relationship risks. Author concluded that risks are directly proportional to logistic function being outsourced. The more the logistic function outsourced, the higher the risk is. When engaging in a single transportation outsourcing, the outsourcers perceived asset risk to be more important than competence risk. However, when engaging in a multiple-function outsourcing, the outsourcers raised these two risks to a very similar level.

3.3.7 FASHION & CLOTHES SECTOR

(Omera khan et al 2008-b) analyzed various risk assessment tools and their impact on supply chain risk in a major UK retailer. (Omera khan et al 2008-a) is the first one who argued about the impact of product design in SCRM. Through case study approach, author concluded that product design led is important strategy that needs to be considered when designing and offered a novel approach for risk mitigation in supply chain.

Information systems always play significant role in supply chain in terms of advanced planning and scheduling that would further minimize risks also. (A. Brun et al 2006) discussed an information system use for advanced planning and scheduling and supply chain management (APS/SCM) with the help of proposed methodology .The methodology is based on the consideration that activities whose execution can be supported by APS/SCM solutions may have an impact on the key performances of a supply chain.

(Sameer Kumar et al 2007) discusses the outcomes and impacts of the occurrence of major supply chain risks from both a macro and micro point of view while outsourcing in China.

Table 4: Summary of Automotive and Logistics & Transport sector

Automotive Sector	S.M. Wagner et al(2009-b)	Supplier default dependencies	Supplier bankruptcy,	supplier development with relationship specific investment and upgrade supplier's performance, creation of a backup supply base of independent suppliers such as located at different parts of worlds etc.
	J.-H. Thun et al	status quo of SCRM practices in germany	Internal risk, external risk	Reactive instrument and preventive instrument
	Berry, A(2007)	Risk management in Automotive	Relationship risk and performance risk	
	Canbolat, Y. B. et al 2008	Supply risk analysis	Sourcing risk	FMEA and simulation tool
	Jennifer 2008 et al	Identification and assessment of Risky products/parts and supplier	Internal and External risks, Disruption /Disaster, logistics, supplier dependence, quality, information system, forecast, legal, intellectual property, procurement ,receivable, capacity and Management security	Author proposed a methodology based on multi criteria scoring method for supplier risk assessment and monitoring
	P.Trkman et al(2009)	Assessment of supplier risk in turbulent environment	Endogenous risks[market turbulence and technology turbulence] and Exogenous risks[continuous and discrete risks]	Conceptual model for measuring supplier performance, Closer relationship with suppliers
Logistics & Transport Sector	D. Ekwall et al(2009)	Cargo theft in transportation network	Environmental risk , Theft	Total crime displacement, modus operandi
	Tsai, M. C et al(2008)	Identification of risks in logistics	asset risk[information risk, loss of control, employee resistance, inactive logistic facility,] relationship risk[vendor opportunism, contractor violation, poor communication, lack of shared goals] and competence risk[poor competence leverage, poor competence in supporting customer services, poor competence protection]	Comparison of In house Vs outsource logistics risks
	Kumar, S(2008)	Cargo theft	Environmental risk , Theft	Six Sigma
	Ojha&gokhale et al(2009)	Managing risks in logistics	Logistics risks	Logistic Business Continuity Planning
	V.S.Rodrigues et al(2010)	Risk in transportation network	Supplier uncertainty, customer uncertainty, carrier uncertainty, control system and external uncertainty	Strategic optimization, operational optimization, quality management tools, forecasting tools

(R. Masson et al 2007) examined the agile supply chain management practices adopted by UK clothing retailers. Various risk management practices and agile practices such as market sensitivity, postponement activities and collaborative information-sharing partnerships are used in early product definition and the later product delivery stages of the supply chain. However, the responsibility for supply, including the key aspect of managing the complex supply network, was almost exclusively left to intermediaries located in low-cost countries. These intermediaries in the main could best achieve agile supply from a significantly underutilized low-cost country supply network through a traditional adversarial price and lead time auction sourcing process.

3.3.8 PHARMACEUTICAL SECTOR

(Enyinda, C. I.2010) reported various findings related to quantification of risks and risk management strategies obtained through empirical analysis performed in global pharmaceutical supply chain. The author suggested that decision maker considered great importance to counterfeit, Food and Drugs Board, and exchange-rate fluctuations. Risk reduction and risk avoidance are considered most important treatment strategies

(Breen, L. 2008) indicated thirty five prevalent risks identified from data collected in research workshop. The risks were rated using risk assessment categories such as impact, occurrence and controllability. The findings indicated that the risks identified are similar to those prevalent in industrial supply chains, regardless of the idiosyncrasies of pharmaceuticals. Caution must be applied in how such risks are addressed, as there are aspects of the product that highlight its uniqueness e.g. criticality.

(Deane et al 2010) examined medical supply chain risk exposure In particular, data from six pharmaceutical companies and eight healthcare organizations is combined with input from security experts to determine the current degree of IT security risk. In addition, author examined an optimal strategy to reduce overall risk and the amount of supply chain risk due to partnering.

(Leopoulos et al 2006) provided various implications on risk treatment strategies used by Greek firms especially in pharmaceutical supply chain, such as electronic alliance between firms to mitigate various global risks and threats. Author presented different threats and opportunities that may effect this e alliance.

3.3.9 FOOD SECTOR

(Laeequddin et al 2009) proposed a framework for building trust in supply chain's partners by considering various risks. The five key perspectives used for risk evaluation are characteristics, economics, dynamic capabilities, technology and institutions.

(Enrico Briano et al 2010-b) described the findings obtained through a simulation model designed for an Italian food supply chain. The author addresses criticalities and risks involved in it and with the objective minimizing total cost and maximizing profit of supply chain. With the help of software, author simulated various scenarios and strategies and concluded that procurement from two different suppliers located at different geographical areas appeared to be an effective strategy even in the case of catastrophic events.

(L. Jacxsens et al 2009) presented a conceptual approach to analyze the complexity of the climate change and globalization challenge on the fresh produce supply chain. The current quality assurance and control tools and methods to prevent and/or to control microbiological risks associated with fresh produce are challenged due to the following pressures upon the food supply chain, i.e. changing consumption patterns, globalization and climate change. It demonstrates the need for scientific research and development of new and/or improved tools, techniques and practices to adapt the current risk management systems The proposed knowledge-based modeling system is believed to be a most appropriate way to identify problems and to offer solutions to monitor and prevent microbiological food safety risks during all phases of food production and supply. To explore the potential impact of climate change and globalization, baseline information can be obtained by surveillance and performance measurement of implemented food safety management systems. Simulation of climate change scenarios and the logistic chain of fresh produce, along with mathematical models to optimize packaging technology to maintain quality and safety of fresh produce are tools to provide insights in the complex dynamic ecosystem.

(Voss, M. et al 2009) assess whether and under what conditions firms in the food industry are willing to tradeoff price and delivery reliability in return for greater supplier security.

3.3.10 EPC SECTOR

After making the decision for outsourcing, supplier selection is next phase that could generate various risks later on if not done properly. (Micheli et al 2008) tried to establish link between Supply risk management and supplier selection in Engineering, procurement and construction EPC supply chain.

They found that supplier selection considered as a part of supply risk management process under some resource constraints by various firms. Also, supplier selection and supply risk management is being used by firms alternatively for mitigation of supply risks. Risk sources are categorized as product related, market related and supplier related. Author also generated two dimensional interpretive matrix which allows to identify different quadrants in matrix each characterized by different focuses on SS and SRM. Author found that key contextual factors which companies to focus on SS and SRM are project orientation in supply management, use of partnerships with suppliers, corporate standardizations and need of co design.

3.3.11 AVIATION SECTOR

(D. Weiss, et al 2009) investigated that how a firm's operational policy hedges it from severe disruptions. Firms must manage their operations in a way that responds to uncertain demand in an effective manner. Authors used Lower tail stochastic dominance (LSD) concept for ranking the firm's hedging level.

3.3.12 NON PROFIT SECTOR

(Ron McLachlin 2009) tried to analyze that if various techniques used for commercial supply chain can be used in nonprofit organization in interrupted environment. Authors used grounded research methods and case based research methods to understand the relationship between these two supply chains.

3.3.13 PAINT SECTOR

(D. Elangovan 2009) proposed an efficient responsive supply chain risk management model that protects from major time delays in paint supply chain. The author also recommended various measures as an corrective strategies to mitigate such time delays.

3.3.14 PETROLEUM SECTOR

(Adhitya,A et al 2007-a) and (Adhitya,A et al 2007-b) developed a heuristic rescheduling strategy that helps not only in making schedule within short period of time but also when data sets change due to disruption , the schedule is developed according to these changes. The idea

behind such strategy is any schedule can be broken into operational blocks. By modifying these blocks, new schedule can easily be developed (Nathan, J. 2008) argued on various challenges associated to oil Supply chain in Kazakhstan and indentified risks such as political, technological and financial risks.

Table 5:Summary of EPC, Paint, Petroleum, Fianance, aviation, non profit and Chemical Sectors

EPC Sector	Micheli et al(2008)	Existence of link between the use of supplier selection (SS) and supply risk management (SRM)	Product related, market related , Supplier related	supply risk can be managed through both SS and SRMproject orientation in supply management, use of partnerships with suppliers, corporate standardizations and need of co design.
Paint Sector	D. Elangovan(2009)	protection from major time delays in paint supply chain	Environmental risk	Efficient responsive SCRM model
Petroleum Sector	Adhitya,A et al.(2007-a) Adhitya,A et al.(2007-b)	Optimal schedule, disruption in schedule	Disruption risks	heuristic rescheduling strategy
	Nathan, J. (2008)	challenges associated to oil Supply chain in Kazakhstan	political, technological and financial risks	political, technological and financial risks are major issues
Finance sector	M. Eric Johnson(2008)	disclosure and leak risks in any peer to peer file sharing network	Information risks, Environmental risk, disclosure risk, leak risk	analysis demonstrates substantial threats and vulnerability to large firms There was a significant link between firm visibility and threat activity.
Aviation Sector	D. Weiss, et al(2009)	investigates operational hedging against severe disruptions to normal operations in airline industry	Operational risk, Disruption risk	operational hedging vehicles (fleet standardization, high-fleet utilization, an aircraft ownership policy rather than leasing, and international operations) are more powerful in protecting firms than using financial instruments
Nonprofit Sector	Ron McLachlin(2009)	if various techniques used for commercial supply chain can be used in nonprofit organization in interrupted environment	Environmental risk	. Authors used grounded research methods and case based research methods to understand the relationship between these two supply chains
Chemical Sector	Reuter et al 2010	role of purchasing and supply management for firms's sustainability to avoid the risks	Supply risk	Author tried to identify how PSM function integrates sustanbility in its global supplier management to achieve competitive advantage.

Table 6: Summary of fashion & clothing, Food, Pharmacy, Electronic & Aerospace, Electronic & Automotive sectors

Fashion & Clothes sector	A. Brun et al(2006)	Value Assessment of information system APS/SCM system's application in a Supply chain.	Precarious market conditions, Poor data quality, Unforeseen events in manufacturing, Late supplies,Workforce resistance to change ,Inertia in vendors monitoring ,Poor planning by vendor , Temporary unavailability of workforce, Late supplies by vendor, Vendor not reliable, Quality problems with suppliers , Inertia in scouting alternative, suppliers Increment in outsourcer, Temporary unavailablity of workforce Internal failures (forgettings), anticipated communication	Propose a methodology for value assessment
	Sameer Kumar(2007)	Risk associated to US-China trade partnership	Macro Risk [Economic risk, geopolitical risk] and micro risk[operational risks]	Identified risks from macro and micro 's perspective environmental risks and proposed specific strategies
	R. Masson et al(2007)	Complexity in adopting Agile supply chain practices	Supplier network complexity	market sensitivity, postponement activities and collaborative information-sharing partnerships
	omera khan et al(2008-a)	Effect of product design in SCRM	Critical risks, High risks, medium risks, low risks and very low risks	A framework for design led supply chain risk management
	omera khan et al(2008-b)	Managing risk associated to major retailer firm	Bringing design in-house where this had been previously done by the supplier; Planning and forecasting; Regional office manager capability (in country), IT infrastructure Barriers to communication overseas mitigated when in-country regional offices were set up , Working with both full service vendor suppliers and direct suppliers in the country of origin , Tracking the end to end benefits and costs to monitor scope and cost creep. The right logistics model to support new buying	risk assessment and management tools to improve agility
Pharmaceutical Sector	Enyinda, C. I.(2010)	Risk assessment in pharmaceutical supply chain	Food and drug board risk, counterfeit risk, Exchange rate risk, currency risk, supplier failure risk	Risk reduction and risk avoidance, Risk acceptance , Risk transfer
	Deane et al 2010	Assessment of IT risk in Medical supply chain	IT security risk	Optimal strategy
	Breen, L. (2008)	Identification of risks in Pharma industry	Risks associated to pharmaceutical supply chain,	
	Leopoulos et al(2006)	Risks in Pharmaceutical supply chain	External risk, Internal risks	Electronic alliance
Food Sector	Laeequddin et al(2009)	Building trust in supply chain partners	Relationship risk	Risk and trust are inter related . trust can not be built as one dimensional phenomena. Characteristics that increase trust
	L. Jacxsens et al.(2009)	Effect of Climate change and globalization in food supply chain	Environmental risk, climate change	Knowledge based modeling system for risk identification and monitoring
	ENRICO	Criticalities and risks associated to	Supply chain vulnerability	Simulated various strategies and

	BRIANO(2010-b)	short life products supply chain		scenarios through systems dynamics
	Voss, M.(2009)	Role of security in food sector	Security breaches, Security failures	assess whether and under what conditions firms in the food industry are willing to tradeoff price and delivery reliability in return for greater supplier security
Electronics & Automoti	Blos et al(2009)	Supply chain vulnerability in automotive and electronic sectors	Operational risks, disruptions risks, financial vulnerability, strategic vulnerability, hazard vulnerability and operations vulnerability	better supply chain communication, SCRM & BCM training program and CRO creation
Electronics & Aerospace	A. Mendes Primo(2010	Supply side issues in electronics and aviations firms	Supply risk	Trust and power mechanisms internal integration between purchasing and manufacturing groups, customer integration
	Craighead (2007)	design characteristics that would make supply chain disruptions severe from one another	Complexity, Density, Node Criticality	Density, criticality and complexity of supply chain . Two mitigating strategies are Recovery and Warning

3.3.15 FINANCE SECTOR

M. Eric Johnson(2008) also discussed disclosure and leak risks in any peer to peer file sharing network. Author concluded that their analysis demonstrates substantial threats and vulnerability to large firms. Author also found statistically significant link between leakage and leak sources including the firm employment base and the number of retail accounts. There was a significant link between firm visibility and threat activity.

3.3.16 CHEMICAL SECTOR

(Reuter et al 2010) analyzed the role of purchasing and supply management for firms's sustainability to avoid the risks of reputational damage for buying company in global sourcing. Furthermore, Author tried to identify how PSM function integrates sustanbility in its global supplier management to achieve competitive advantage.

3.3.17 MULTIPLE SECTORS

Many researchers considered more than one industrial sector for the analysis of SCRM to understand different risk sources from different aspects and proposed mitigation strategies.

3.3.18 ELECTRONICS & AUTOMOTIVE

(Blos et al 2009) investigated supply chain risks in automotive and electronic industries through case study approach. The author classified supply chain vulnerabilities into 4 main types, financial vulnerability, strategic vulnerability, hazard vulnerability and operations vulnerability. To mitigate these vulnerabilities, author proposed some strategies such as better supply chain communication, SCRM & BCM training program and CRO creation. There is no doubt that all supply chain risk is linked to performance of supply chain. Many author tried to investigate the affect of different risks with the performance.

3.3.19 ELECTRONICS & AVIATION

Design of any system or product plays an important role in classifying the products or systems as more or less risky. (Craighead et al 2007) tried to figure out those design characteristics that would make supply chain disruptions severe from one another. Author

concluded that three design characteristics (density, complexity and criticality) are directly proportional to supply chain disruptions. i.e. more critical a node is, more likely to be disrupted by unplanned event. Density of supply chain represents the geographical area any supply chain cover and locate. Such as a supply chain is said to be denser if its entire network is located within same geographical area or nearby. A supply chain is said to be more complex if all its business players are located faraway from each other. A particular node or player of supply chain is more critical if it has strategic importance for a whole supply chain, such as supplier of critical spare parts. Authors also pointed two mitigating strategies (recovery and warning) and found that they are inversely proportional to supply chain disruptions. i.e more recoverable a system is, less likely to be interrupted by risk.

(Mendes Primo et al 2010) analyzed the importance of integration mechanisms between manufacturing firms and their suppliers that reduce supply risks. Author presented some drivers and managerial implications on this. Author concluded that trust and power mechanism can be used to accomplish supplier commitment which is an important aspect of mechanism. Other important factors are internal integration between purchasing and manufacturing groups, customer integration etc.

3.3.20 MULTIPLE SECTORS (OTHERS)

(S.M.Wagner et al 2008) presented various risks from literature and after incorporating them into questionnaire tried to establish the link between risks factors and performance. The author divided the risks into five main categories, demand side risks, supply side risks, regulatory, legal and bureaucratic risks, infrastructure risk and Catastrophic risk. Author further concluded that the risks associated to demand side and supply side got great influenced on supply chain performance and remaining three were not affect the performance as much. (Wagner et al 2006) surveyed more than 760 executives in order to understand the relationship between supply chain characteristics and risks. With the help of literature, author classified risks as supply sided, demand sided and catastrophic risks. Author further identified risks drivers as customer dependence and supplier dependence, Supplier concentration and single sourcing and global sourcing. Author further explored the link between these risks and drivers. Main findings are customer dependence is positively related to demand side risks while risk derived from supply-side risk sources is elevated by supplier dependence, single sourcing, and global sourcing.

(C. Reade et al 2009) argued that Supply chain risks severely affect the supply chain management through every aspect. Such as demand side, supply side and operational side etc. However, they also affect the employees in firms. In this article, authors analyzed the relationship of employee sensitiveness to terrorism activities and their attitude in high risk environments. Authors constructed 7 main hypothesis representing authors attitude toward organization, team and job. These hypotheses were then verified with the help of interviews taken from different industries in Sri Lanka. (S.C. Ellis et al 2010) proposed a framework for development of views of supply disruption risks with the help of behavioral risks theory. The authors examined the relationship among situations, risks representations and decision making process. The three representations of supply disruption risks are magnitude of supply disruptions, probability of supply disruptions and overall supply disruption risks. Authors also identified product and market factors that impact on buyer's perceptions and the overall effect of representation of risks on buyer's decision

The need of design in supply chain gains a lot of importance in terms of design of supply chain structure, design of products etc. The design of a product can have implications in terms of component or material availability and also in capacity. (Omera khan et al 2009) investigated the impact of product design on supply chain through case study approach conducted at different industrial sectors and showed that successful companies always seeks for design into all aspects of their businesses. The author proposed a roadmap that leads to design centric business. According to that roadmap, products are designed concurrently with supply chain so that implications from upstream and downstream supply chain taken into account. Author further proposed 4c approach for transformation of traditional structure to design centric structure, champion for product range, cross functional team, cooperation in the extended enterprise and co-location of concurrent design teams. Companies that are part of global supply chain are more risky compare to local supply chain or Individual Corporation. (Hameri, A. P 2009) reports findings conducted through a study from literature review and surveys on the global trends and changes in future supply chain. Their main findings are related to increased off-shoring of operations through truly global manufacturing, characterized by its intercontinental supply of materials; increased product complexity with shorter product life cycles; increased importance of business-to-government networking for operational and security efficiency; introduction of new supply chain services integrating financial, physical and information flows leading to further consolidation in the logistics markets; and the overall increase in risks and vulnerabilities in international supply chains.

(Lim, S. H.et al 2009) investigated various organizational factors that need to be considered before implementing RFID . These factors included Risk factors, performance measure and their impact on business performance.

(Illa manuj et al 2008-b) argued that global supply chain is more risky than domestic due to those risks that could occur globally, such as disruptions, bankruptcies, breakdowns, macroeconomic and political changes, and disasters. Author explored the phenomenon of risk management and risk management strategies in global supply chains.

(Autry & Bobbit et al 2008) reports findings on supply chain security orientation addressing companies' approaches towards security breaches and SCRM. Key antecedents, outcomes and moderating conditions were identified through case study approach.

(Skipper, J 2009-b) identified and compared those characteristics of firms that adopt supply chain contingency planning and that do not adopt. Authors further identify key predictor variables of contingency planning process.

(Urciuoli, L. 2010) argued and provided complete insight into security solutions that are being used by the firms to protect their distribution chains from risks of being stolen, counterfeited or contaminated and terrorist threats etc. Besides identifying weak spots and issues in distribution chains, author provided managerial recommendations for preventing them from such risks and threats.

A very important aspect of research in retail supply chain could be what are different types of risks associated to retail supply chain and what specific and generic strategies are currently being used by firms. (A.oke et al 2009) considered a retail supply chain and Categorize risks into three main categories, supply, demand and miscellaneous risks. Author further classified sub categories of these risks into high likelihood low impact risks and low likelihood high impact risks. Based on these classifications, author proposed generic and specific strategies for mitigation of these risks. Specific strategies focus o n efficiency gin and cost reduction and generic strategies focus on better planning and coordination between demand and supply. Author further proposed that specific strategies may be used to mitigate miscellaneous risks. Generic strategies can be used to mitigate high likelihood low impact risks and low likelihood high impact risks.

Bhattacharyya et al 2010) explored various issues regarding countries specific risks vs third party indices and their impact on supply chain. Author proposed seven third-party indices and used them on secondary data obtained from 81 member countries of the World Trade Organization (WTO) using archival data collected from UN agencies, independent think tanks, the WTO, and the Economist Intelligence Unit. Author concluded that third party

indices are being used for assessing country operational risk but also operational risk has negative impact on import and export supply chain.

(Zhou, K. et al 2010) analyzed various practices used in buyer supplier exchanges about legal enforceability and concluded that the use of contract is being increased to safeguard market exchange from hazards and risks such as opportunistic behavior from counterpart etc. Other useful findings are explicit contracts are used in environment by manager s when they satisfy with legal system in term of protection of their interest. On the other hand, they rely on relational reliability to safeguards their interests instead of writing contract when they do not satisfy with legal system.

(Vanany et al 2010) conducted case study using structured in Indonesian manufacturing firms and concluded that most of managers now perceived the importance of SCRM in their businesses and believe that they could not fulfill the demand if supply chain risks occur. Therefore, companies should adopt treatment strategies that can mitigate risks.

(Martin et al 2011) explored that most companies do not use any formal risk management process to cope with supply chain risk during global sourcing. With the help of multiple case study approach conducted at different manufacturing industries, author classified risks into supply, process, control, environmental, sustainability and demand risks. Furthermore, author has emphasized on the need of multi disciplinary approach for SCRM.

(Blome et al 2011) provided general overview and assessment of SCRM on economic and financial aspects of firms and check the applicability of SCRM. Furthermore, the author analyzed relationship between enterprise risk management and supply chain risk management. Author concluded that SCRM are being adopted by manufacturing firms during financial crises compare to service firms due to their less dependency on suppliers. (Wendy L. Tate 2009) presented a managerial framework for supplier selection and purchasing services from offshore suppliers. Author concluded that selection process should be strategic in nature that helps firms to get quality services with low cost but also reduce risks and complexities.

(Tse et al 2011) discussed issues raised from quality perspectives of different products in global supply chain. According to author, the quality issue gets worse due to low visibility of quality risks in any supply chain as they are many business partners involve in the process such as from raw materials suppliers, manufacturing processes, or logistics operations etc. This risk can be minimized by making visibility better. Author proposed an integrated framework for product quality risk and visibility assessment framework.

(S. Pavlou et al 2008) explored risks by considering detrimental events as risk sources and developed an information systems risk strategy. These risks sources were then classified according to their types and were mapped against SCOR Model. (Ratnasingam, P. 2006) analyzed risk associated to e- commerce in supply chain activities. The author identified four types of risks namely technological, organizational, implementation and relational risks. Besides risk identification, author highlights factors that contribute to risks and consequences also.

Table 7: Summary of Multiple Sectors(others)

Multiple Sectors	Lim, S. H.et al(2009)	Impact of RFID on organizations	Risk associated to RFID [Managerial risks & technical risks]	management of organizational fit factors in connection with perceived risk levels has a significant effect on the perceived impact of RFID on business performance.
	Bhattacharyya et al 2010	Effect of Country' operational risk on export supply chain	Operational risks, Environmental risk	
	A.oke et al(2009)	Investigation and management of risk faced by US retailer	inherent or high frequent risks and disruption or infrequent risks Supply risks, demand risks and Miscellaneous risks,	Proposed specific and generic strategies associated to risks
	Hameri, A. P.(2009)	Drivers of change and implications on supply chain in coming decades	Energy concerns, Environmental concerns and regulations Global pandemics and natural hazards Information and data management complexities Manufacturing and low cost labor Raw material concerns Security concerns and regulations Technical trade barriers	They are related to increased off-shoring of operations through truly global manufacturing, characterized by its intercontinental supply of materials; increased product complexity with shorter product life cycles; increased importance of business-to-government networking for operational and security efficiency; introduction of new supply chain services integrating financial, physical and information flows leading to further consolidation in the logistics markets; and the overall increase in risks and vulnerabilities in international supply chains.
	Autry&Bobbit et al(2008)	Supply chain security orientation	Security vulnerability, Supply vulnerability and Asset property vulnerability, Human factor risk, Disaster risk, information /systemic risk and legal government risk	Key antecedents, outcomes, and moderating conditions were identified
	Wagner & Bode et al (2006)	Relationship between supply chain vulnerability and risks	Supply side , demand side and catastrophic risks	Main findings are customer dependence is positively related to demand side risks while risk derived from supply-side risk sources is elevated by supplier dependence, single sourcing, and global sourcing.
	Skipper, J(2009-b)	Identification & comparison of characteristics of firms adopting contingency planning process with those that do not	Organizational Barriers to contingency planning	Author used Rojer's innovation diffusion variables along with 2 additional variables and verified them empirically
	S.C. Ellis et al(2010)	Buyer perception of supply disruption risk	Supply risk, Environmental risk, Technological uncertainty, market thinness	results show that both the probability and the magnitude of supply disruption are important to buyers' overall perceptions of supply disruption risk product and market, situational factors impact perceptions of risk, but they are best understood through their impact on perceptions of probability and magnitude.
	C. Reade et al (2009)	analyzed the relationship of employee sensitiveness to terrorism activities and their attitude in high risk environments.	Environmental risks, Terrorist attack	Authors constructed 7 main hypothesis representing authors attitude toward organization, team and job. These hypotheses were then verified with the help of interviews taken from different industries in Sri Lanka
	martin et al 2011	Assessment of global sourcing risk	Process risk, control risk, environmental risk,	The study proposes four generic strategies for from managing global

	and mitigation strategies	sustainability risk and demand risks	sourcing risk: network re-engineering, collaboration, agility and a risk management culture
Blome et al 2011	Management of supply risk during financial crisis Link between ERP & SCRM	Supply risk	service firms are mainly influenced by the financial crisis on the demand side, whereas manufacturing firms are affected by the demand *and* the supply side.
Urciuoli, L. (2010)	risks of being stolen, counterfeited or contaminated and terrorist threats during logistics perspective et c	Environemntal risks, Stolen, terrorsits, etc	Besides identifying weak spots and issues in distribution chains, author provided managerial recommendations for preventing them from such risks and threats.
Tse et al 2011	issues raised from quality perspectives of different products in global supply chain.	Quality risk	This risk can be minimized by making visibility better. Author proposed an integrated framework for product quality risk and visibility assessment framework.
Wendy L. Tate(2009)	Supplier selection and Purchasing process in global sourcing	Supply side risk	Purchasing process
Ratnasingam, P. (2006).	risk associated to e- commerce in supply chain activities	technological, organizational, implementation and relational risks	Author identify and highlights factors that contribute to risks and consequences also.

3.4 MAIN FINDINGS

Previously, we have talked about that a supply chain can be attacked or vulnerable to threats through 4 main sides. Supply side, demand side, internal side and environmental side. In fact each and every single threat address by authors or academicians can be placed to any of these four categories. Therefore, to summarize our main findings we have adopted this classification in order to understand which source is addressed a lot by authors and where gap exists. Furthermore, we dig each source into sub classification to understand which specific area requires more attention. In this regard, the following pie chart clearly showing the articles distribution based on above risk classification.

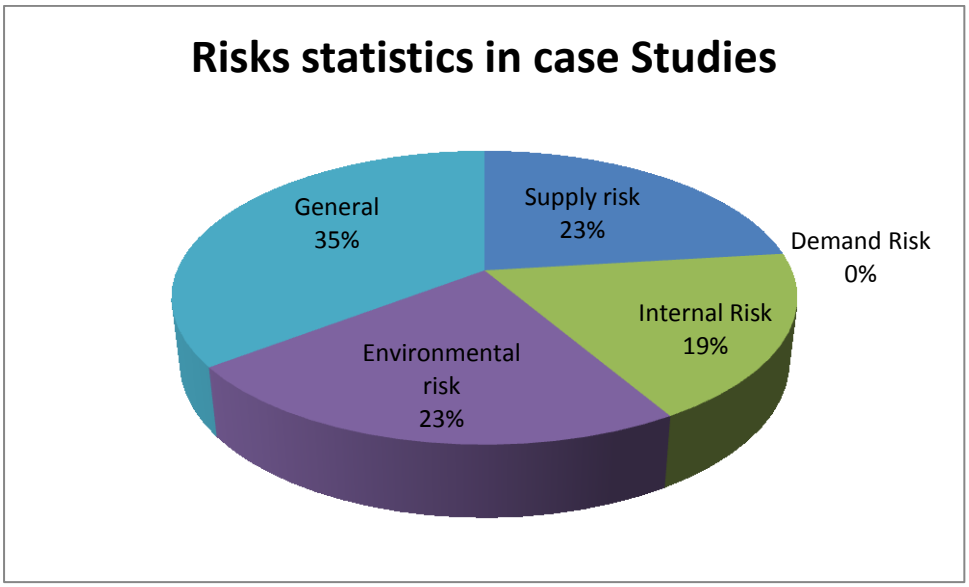


Fig 5: Risk statistics in Case studies

Supply side and environmental risks are equally addressed by authors that also show the importance and strategic significance of both types of risks. Surprisingly, we did not find any article that addresses uniquely demand side risk even though of having significance strategic significance in supply chain. However, we have found many articles that talked about demand side risks with other types. We have placed all such articles in general categories where author usually presented an overview on all sides of risks. After supply side and environmental side, internal side is addressed by many authors also.

The risk associated to supply side or upstream supply chain has been discussed most in the case studies. Besides discussing partially with other sources of risks, we found 15 articles that address completely supply side related issues. Risk from supply side generally arise associated to outsourcing processes when an entity in any supply chain try to make alliance with other business partners to achieve competitive advantage. It could be in any type or form

of different processes or services. Most commonly type of processes or services firms outsource are logistics activities, IT and maintenance etc. Furthermore, companies try to establish their manufacturing facilities to cheap labor countries for gaining cost advantages. The whole supply chain suffers if any disruption occurs to such facilities. Such disruption also considered in supply risk. Any outsourcing process can be generally divided into pre contracting phase, contracting phase and post contracting phase. A pre contracting phase consists of two main elements of a process decision making process where firms decided to outsource their functions or processes and considered various risks in this regard. Once they decide about outsourcing process, they tend to select risk free supplier or business partner. After selecting a supplier, they write a contract with partner and eventually try to manage the relationship with supplier until contract termination. A pie chart with showing statistics of all 4 phases is presented below.

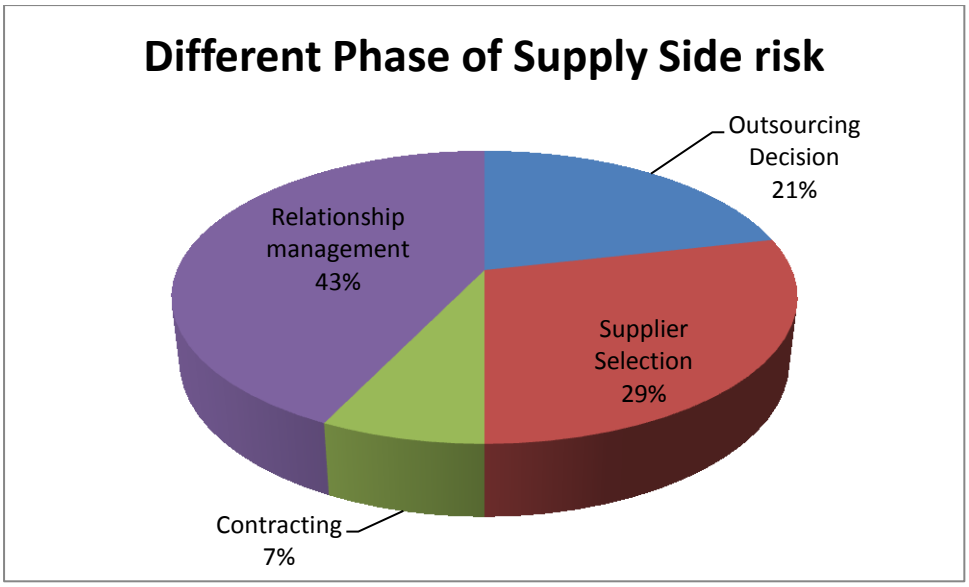


Fig 6: Different phases of Supply side Risk

Many author discussed aspect of outsourcing process from emerging markets. In this context, they have identified risk associated to outsourcing in these markets and descision making process as well such as discussed by (Tobias et al 2008) , (martin et al 2011) and (Wendy L. Tate 2009) and (Canbolat, Y. B. et al 2008). furthermore, proposed strategies to handle such issues. Supplier selection is next important step for firms to tackle with. The literature is full of those articles those mentioned various characteristics need to be considered during supplier selection. Our focus was those articles only that considered risk in selection process. Such as (R R.Levary et al 2008), (Micheli et al 2008), (X.Li Barnes et al 2008), (Chris Ellegaard et al 2008), (Jennifer et al 2008), (P.Trkman et al 2009). Besides discussing implications of risk, they have also proposed managerial frameworks, conditions under which firms are willing to

tradeoff price and delivery reliability in return for greater supplier security and many mitigating strategies.

When firms and suppliers across a supply chain get together, they tend to have such contracts that not only maximize their profits but allow them to make decisions independently with minimizing risks also. (Manoj, U. V 2009) analyzed various contracts types in the case study.

Many authors discussed and analyzed supply chain risk management in a Relationship management context such as (S.M. Wagner et al 2009-b) supplier default, (R. Masson et al 2007) Complexity in agile practices through supply side (A. Mendes Primo 2010) , (Blome et al 2011) Supply risk during financial

Demand side risks come from downstream side of supply chain in the form of change in customer demand or forecasting error. To the best of our knowledge there is no any article which addresses any aspect from demand side alone. However, this risk source is addressed with other risk sources couple of time. The demand side risks are analyzed with other sources are in (G.Tuncel et al 2009), (Ritchie et al 2007b), (Illa manuj et al 2008-b) ,(Nagali, V.et al 2008), (MS Sodhi 2007), (J.-H. Thun et al 2009), (Tsai, M. C et al 2008), (V.S.Rodrigues et al 2010), (Leopoulos et al 2006), (Blos et al 2009), (A.oke et al 2009) and (Wagner & Bode 2006)

Internal risks are refered to organizational internal risks such as process risk, control risks etc. Internal side risks refer to firm's internal risk that becomes vulnerable for whole supply chain. An important aspect is the design process due to which internal risk arises. The design of product, process or supply chain itself can either leads to vulnerable supply chain if not appropriate, or leads to resilience supply chain if risks are considered during design phase.

Design of any system or product plays an important role in classifying the products or systems as more or less risky. Firms can achieve competitive advantage by designing innovative products. (Lee, R. P. et al 2010), (Omera khan et al 2009) and (Omera khan et al 2008-a) argued about design concept in SCRM and proposed its implications and risk management strategies. Internal risk also arises due firm's own resources, capabilities and processes and organizational culture incompatible to supply chain needs, such as discussed by technical challenges faced due to organizational barriers by (M. Loosemore et al 2008), (Nagali, V.et al 2008), (Skipper, J 2009-b), and (Tse et al 2011). Organizational performance plays a key role in mitigating ior arising of internal risks. (Berry, A 2007). Firms own IT capability and information system is also addressed by (A. Brun et al 2006), (Deane et al 2010), (Voss, M. 2009) and (Lim, S. H.et al 2009).

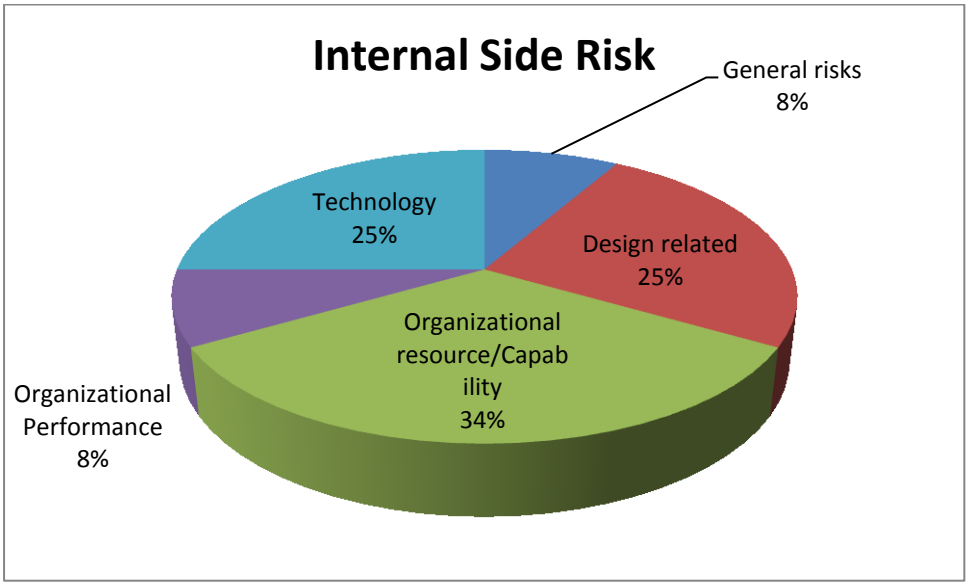


Fig 7: Internal Side Risks

Environmental risk also known as external risks arise due to external factors such as catastrophic events, government regulations etc (Manuj et al 2008). We have further classified articles into three sub classes, High severity low frequency risks such as disasters, catastrophic events, Low severity high frequency risks such as terrorist attacks, accidents, port delay etc and finally country risks which covers political, legal, currency and other risks as well.

For High severity low frequency risks (I.S.Papadakis et al 2006) and (L. Jacxsens et al. 2009) analyzed various implications of catastrophic events and their effects on supply chain. Low severity high frequency risks are addressed by (D. Ekwall et al 2009), (Kumar, S 2008), (Craighead et al 2007), (Bhattacharyya et al 2010) , (Urciuoli et al 2010) ,(Adhitya,A et al 2007-a), (Adhitya,A et al 2007-b) and (Ron McLachlin et al 2009). Finally country specific risks are addressed by(Hameri, A. P 2009) and (Sameer Kumar et al 2007).

The concept of agile supply chain is tremendously increasing in terms of research and industrial practices. How agility can reduce supply chain risks, how it can be achieved and many different agile practices are mainly discussed by (A.S. Oyegoke et al 2008) , (R. Masson et al 2007) and (Samir Dani et al 2008).

Many authors proposed various tools and techniques for different stages of risk management process.i.e Risk Identification, Risk evaluation and Risk treatment. The goal of risk

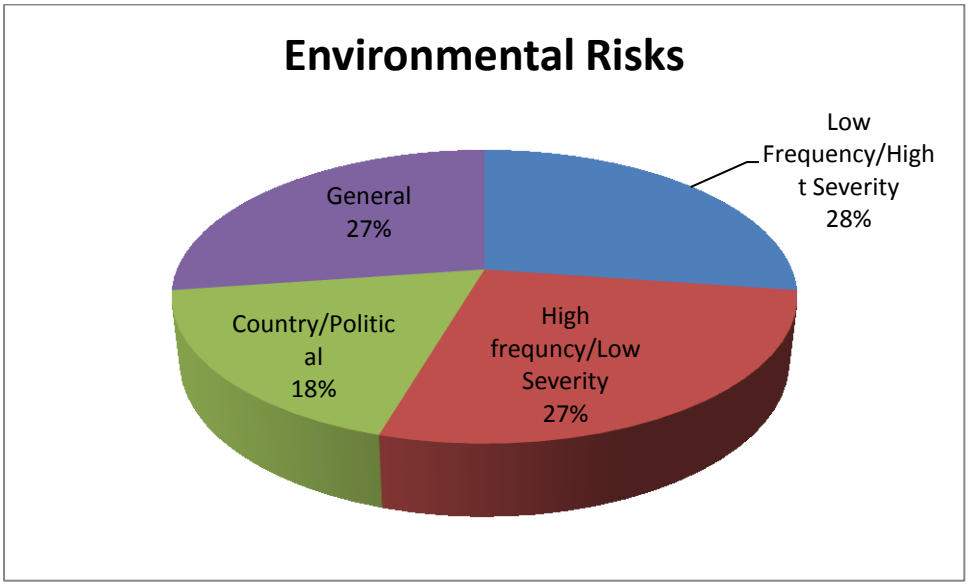


Fig 8: Statistics of Environmental Risks

identification is to develop a detailed list of risks that affect the objectives of Supply chain management. It includes the identification of risk source from within or outside of the Supply chain. A variety of techniques are presented in the literature by academicians. The most important technique used by in literature is method of surveying/questionnaire and interviews. Following article discussed (Jiang et al 2009), (Tuncel et al 2009), (X.Li & I.Barnes 2008), (Loosemore et al 2008), (Thun et al 2009), (A.oke et al 2009), (Tsai, M. C et al 2008), (Breen, L. et al 2008), (A. Brun et al 2006), (Lim, S. H.et al 2009), (S.M.Wagner et al 2008),(Autry & Bobbit 2008). Another famous tool is Delphi technique used by (Tsai, M. C et al 2008), (Hameri, A. P. 2009). Another important risk identification tool is Action Research (AR) used by (Tobias et al 2008). Action research is a qualitative research technique in which the researcher actively participates in and influences ongoing organizational processes, but intermittently steps out of the system to obtain a broader perspective (Ottosson et al 2003). The researcher can thus be described as an outside agent, taking action and creating knowledge at the same time, who acts as a facilitator in an organization (Coughlan and Coghlan, 2002). Some of the quality tools such as process mapping and cause and effect diagram are used by (Kumar, S 2008), (Kumar, S 2007) for identification purposes. The concept of simulation software used for identification is also gaining importance. Different real life scenarios are simulated and risks are identified such as used by (Briano 2010-b). Another way of risk identification is to investigate different databases consists of Literature review, electronic resources and newspaper etc, such as done

by (Hamid Mohtadi et al 2009). Supply chain vulnerability map is also useful in order to detect risks at supply chain level (Blos et al 2009). Other tools used are expert opinion combined with historic data or combined with decision maker's opinion, Game theory, catastrophe modeling and real option approach (knemeyar et al 2009).

The process of risk assessment is comprised of analyses phase where usually identified risk at previous stage are assessed not only to prioritize them in term of criticality but also to understand the relationship between various aspects such as checking interdependencies between risks and practices etc. The tools used for that purpose are very similar to risk identification phase, such as the Delphi method or questionnaire/surveying etc. These techniques are used for assessment purpose by (M. Loosemore et al 2008) , (P.Trkman et al 2009), (A.oke et al 2009), (Breen, L. et al 2008), (Voss, M. 2009), (Lim. S. H.et al 2009). The AHP is another method used to assess the criticalities affecting the objectives used by Tobias et al 2008), (Tsai, M. C et al 2008), (Barbara et al 2006) and (Breen, L. 2008). Other qualitative tools use for assessment purpose are risk matrix and risk register by (Omera khan et al 2008-a), Probability impact matrix by (J.-H. Thun et al 2009), Multi criteria scoring procedure and FMEA by (Jennifer et al 2008) and (G.tuncel et al 2009) respectively. Large organizations are using software tools in order to assess different risks when contracting and forecasting demands supply etc. Such as horizon demand scenario software, HP risk component cost forecasting and HP risk contract valuation software used by HP (Nagali, V.et al 2008). Simulation is no doubt an important way to assess the risk such as used by (Briano 2010-b) and (L. Jacxsens et al 2009). Other important tools and ways found in the literature are extreme value theory used by (Hamid Mohtadi et al 2009), conjoint analysis used by (Voss, M. et al 2009) , probabilistic methods used by (A. Brun et al 2006) ,expert evaluation used by (Hameri, A. P. 2009) and supply chain vulnerability map used by (Blos et al 2009), Factorial Analysis/LOGIT by (Jiang et al 2009) , (Petri net tool by tuncel et al 2009)

3.5 CONCLUSION

SCRM has recently gained attention of both academicians and practitioners and is the main topic of this article also. Similarly, Industrial case studies always be an essential source of understanding problems and issues today' business facing with. Without complete and thorough understanding of these issues, academic research would be of no use. It is always crucial for industries especially connected in supply chain to be recognized of risks and threats rising in current turbulent era. According to our analysis, more than 350 journal articles have been published prior to year 2005 only. It is difficult for industrialists to classify the articles according to their needs and requirements through database only. By just typing case studies or empirical analysis on any database would not reveal all SCRM case studies. Hence, this article contributed in many ways

- There are many articles in the databases that contributed toward review of SCRM literature; however, we did not find any article that classified industrial case studies only.
- The papers are classified according to industrial sectors so that researcher or managers can easily identify the articles according to their own industry
- Furthermore, a brief summary of each article along identified risks are also presented separately for the easiness of readers.
- Similarly, various Approaches and treatment strategies adopted by industries expert or proposed by academicians are also enlisted.

CHAPTER 4

IDENTIFICATION OF RM PROCESSES AND RESEARCH ADVANCEMENT IN SCRM: A REVIEW OF QUANTITATIVE MODELS

Overview

In this chapter, we have reviewed various quantitative models for managing supply chain risk published during last 5 years. More than 100 articles are considered for this purpose. Starting from simple linear weighting models to complex optimization models we have reviewed all those articles that considered risk in their supply chain related problems. We first tried to enlist all risk factors separately. Furthermore, the treatment strategies used for mitigation are also summarized. Finally, various future research opportunities are provided.

4.1 INTRODUCTION

Most of the published work in supply chain risk management is based on various types of quantitative models. These quantitative models are usually associated to risk analysis and risk evaluation stages which are the main phases of traditional risk management process. Though risk can be evaluated or analyzed qualitatively as well, but such methods are usually limited in nature and do not provide any exact measures of risks. Quantitative measures usually give precise and objective description of the seriousness of a risk and its consequences.

In this chapter, we have reviewed various quantitative models for managing supply chain risk published after 2005. More than 100 articles are considered for this purpose. Starting from simple linear weighting methods to complex optimization models we have reviewed all those articles that considered risk in their supply chain related problems. We first tried to enlist all risk factors separately. Furthermore, the treatment strategies used for mitigation are also summarized. Finally, various future research opportunities are outlined.

Based on these articles, the following important objectives are achieved.

- Classification of quantitative models with SCRM applications
- Identifications of risks and threats mentioned by authors.
- Approaches and treatment strategies proposed by in these articles.
- and finally comprehensive review of SCRM articles according to a structured framework to determine the gap in research and selection of specific future research areas require attention of academician and SC experts

The rest of the chapter is organized as follows. We first present the methodology of research. The scholarly work done in supply chain risk management was then presented stage by stage. Finally, the chapter is concluded with main findings, discussion for future research and conceptual framework for SCRM.

4.2 APPROACH & METHODOLOGY:

We have performed comprehensive and exhaustive search of the articles related to SCRM published from 2006. There are two main reasons for not including articles prior to 2006. Firstly, the term supply chain risk is relatively new in the literature and got researcher's attention during last few years. Secondly, previously performed literature review by different researchers has already taken care of those articles published prior to 2005 very well. The literature search has been performed through various electronic databases including Science Direct, Emerald Full text, ABI/INFORMS Global Pro Quest, ISI web of Knowledge, Scopus and Inder Science. Different combinations of Key words have been used for search. Such as supply chain risk, supply chain disruptions etc. Articles not belonging to refereed journals such as conference papers, notes, books were discarded.

4.3 MODELING/SIMULATION

4.3.1 MODELING

The Literature analysis enables us to classify quantitative works according to following categories listed below.

- Linear Weighting models
- Hybrid Intelligence/ Systems dynamics
- Statistical/Probabilistic approaches

- Mathematical programming models
- Other optimization models

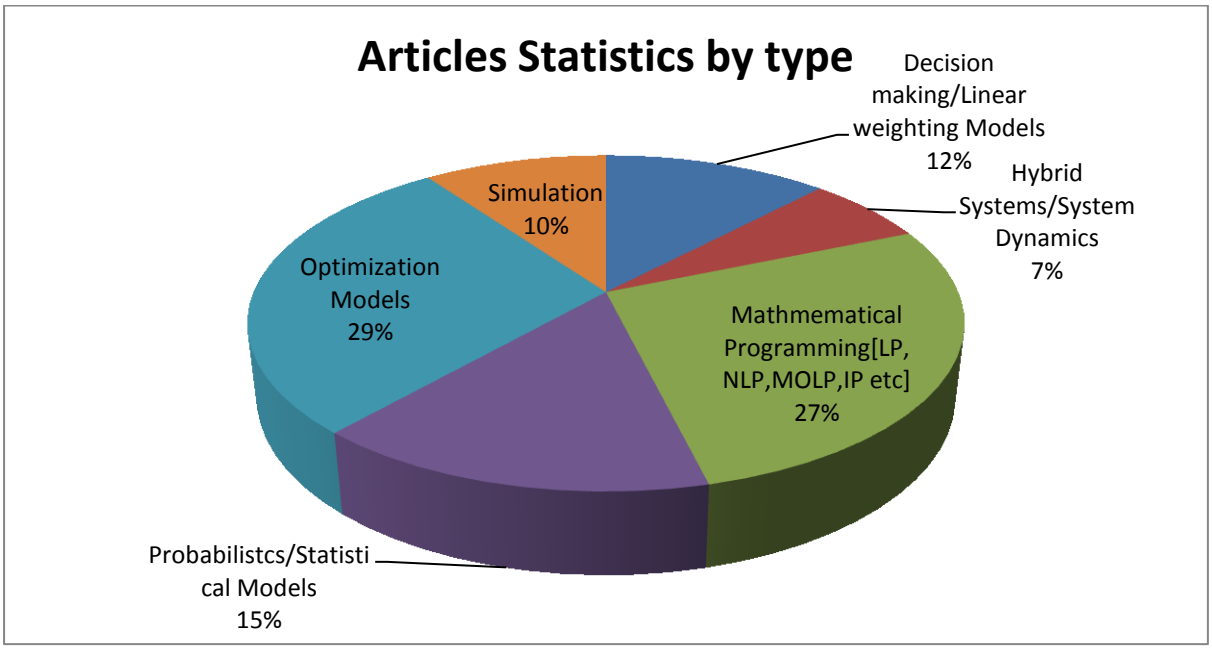


Fig 9: Articles Statistics by type

4.3.1.1 Linear weighting models

These are one of most used approaches for risk identifications and assessment stages in SCRM literature. By assigning different weights to different criteria, we can compute the overall rating of decisional variable (supplier, etc) by considering the weighted sum of different criteria.

(Tobias et al 2008) assessed various risks associated to off shoring process through case study approach in a large US manufacturing firm and proposed a methodology with the integration of action research & analytical hierarchy process techniques. With the help of proposed methodology, author discussed various strategic aspects, such as how outsourcing decision should be made, what are risk sources involved in it and how AHP used to make outsourcing decisions.

Supplier selection is another important step for manufacturing firms to tackle with. The literature is full of those articles those mentioned various characteristics need to be considered during supplier selection. However, (R R.Levary et al 2008) emphasized that risk of disruption to manufacturer's operations must be considered with other important selection characteristics. Through a case study conducted in a manufacturing firm, the author showed that how AHP technique can be used for the selection of suppliers. Risk factor was included

in term of reliability of supplier with various other characteristics. AHP model was used for final selection of suppliers.

Inbound supplies risks refer to those arise from upstream supply chain due to supplier failures or risks associated to suppliers. (Wu et al 2006) presented a complete Risk management framework for supplier where author identified inbound supply side risks through extensive literature review and industry interviews. AHP methodology was used for risk factors classification. In addition to that author developed a prototype computer implementation system for above proposed risk management framework. Risk identification in supply chain is being performed in various ways. However, risks classification or assessment is significantly very important in risk management process as wrong prioritization of risks in turbulent situation or environment can take us to catastrophic situations. Various methods are being used by practitioners and academician for risks assessment. (Gaudenzi et al 2006) developed a model for risk assessment based on AHP technique associated to different supply chain objectives. The different supply chain objectives considered were on time delivery, order completeness, order correctness and damage free and defect free deliveries. Risk factors were identified within each of these objectives and evaluated with AHP methodology. Due to the multidimensional nature of supply risk, analytical tools that can effectively integrate various risk measures into the decision process can prove useful for managers. Therefore various authors integrate AHP with other different approaches and achieved results that were more effective and useful. An important analysis where AHP was combined with fuzzy logic is that of F.T.S. (Chan et al 2007). The author has taken into account different decision criteria like cost, quality, service performance and supplier's profile including the risk factors. The proposed model not only selected risk free suppliers among many but also help organizations to deploy organization's strategy to suppliers. (Kull et al 2008) also proposed a Supply risk reduction model that uses integrated AHP and goal programming tools. The factors used for this purposes are failure in delivery, cost, Quality, flexibility and general confidence. The author uses AHP process for operationalizing multidimensional risk construct, to assess suppliers and for the derivation of risk scores. Then Goal programming is used to evaluate multiple suppliers based on variety of goals .The constructed model was then implemented to automotive suppliers.

Two alternative approaches for explaining U.S. foreign direct investment (FDI) pattern in developing countries are RO and SCRM approaches. According to the real options (RO)

approach, FDI in capital-intensive industries should be particularly deterred by political and macroeconomic uncertainty. On the other hand, the supply chain risk management (SCRM) approach puts forward that multinational enterprises in vertically integrated industries are unlikely to locate their foreign activities in risky countries. (R. Desbordes et al 2007) showed that SCRM approach explains much better the pattern of U.S. FDI in developing countries than the RO approach.

(Ramesh et al 2010) identify the barriers of SCC in the Indian apparel retail industry along with a hierarchy-based model using interpretive structural modeling. Furthermore, author analyzed how these barriers are interacting with one another so that the decision makers can focus on overcoming these barriers and realizing the benefits of SCC.

(Bindu, R. S. et al 2010) proposed a vendor selection model with the inclusion of the concept of relative reliability risk assessment especially for new vendors, where information availability is inadequate to calculate reliability. With AHP, author used multiple attributes of vendor relative measurements. Furthermore, the concept of entropy method for assigning the weight and Alternatives Functionality Graph is introduced.

(Ordoobadi, S. M. 2010) developed a decision model to help decision makers with selection of the appropriate supplier considering both risks and benefits. To resolve the issue of qualitative and quantitative factors, author used a hybrid approach that in the development of the model. Furthermore, author used the concept of Taguchi loss functions to measure performance of each supplier candidate with respect to the risks and benefits. Finally, Analytical hierarchy process (AHP) is used to determine the relative importance of these factors to the decision maker.

(Haleh, et al 2010) proposed a fuzzy multi-criteria model for organising the process of assigning orders to suppliers. The author adopted a fuzzy approach in order to overcome the vagueness of the information due to the uncertainty of them. Furthermore, MCDM methods are used to allocate suitable shares of orders to the best possible suppliers.

(Xia, D. et al 2010) proposed a decision-making model based on the internal triggering and interactive mechanisms in an SC risk system, which takes into account dual cycles, the operational process cycle (OPC) and the product life cycle (PLC). The author explore the inter-relationship among the two cycles, SC organizational performance factors (OPF) and available risk operational practice (ROP), as well as the risk managerial elements in OPC and PLC.

4.3.1.2 Hybrid System intelligence approaches & Systems Dynamics Approaches

These approaches aim to integrate human expertise with qualitative factors when identifying and assessing risks in supply chain. (Ganguly, K. K. 2009) used pattern matching approach of fuzzy set theory for assessing risk. Risks were evaluated using linguistic representation.
(Ma, H. 2007) combines fuzzy sets with influence diagram theory and proposed supply chain risks evaluation method. (Zhang,F. 2006) also deal with prediction risks to improve the forecasting performance of supply chain operations. A linear dynamic system is developed that integrate generic Gaussian noise assumptions with principal component analysis leads to an expectation maximization algorithm to predict demand and estimate model parameters.
(Kumar et al 2010) consider a multi-echelon global supply chain model, where raw material suppliers, manufacturers, warehouses and markets are located in different countries for risk identification and making optimal decision regarding the inter-echelon quantity flow in the supply chain for a single planning horizon. Furthermore, author determine the the intra echelon shift of flow by changing expected value of the risk factors in order to minimize the total cost and risk factors.

4.3.1.3 Systems Dynamics

(D.Bogataj et al 2007) presented a model of risk measurement based on input output analysis and laplace transforms of the supply chain models.
(Sami Kara 2008) developed a framework incorporates both scientific and industrial feedback gathered. A system dynamics approach is utilized which simulates several risks identified in supply chain networks to establish inter and intra-relationships between various risk factors in the entire enhanced network of engineering projects. The environmental, organizational and supply chain networks related issues are considered by developing several influence diagrams for proactive logistics management.

Table 8: Summary of Linear Weighting models

Sector	Author	Issue	Risks identified	Proposed solution/RM Strategy
Decision making models/Linear weighting modes	Tobias et al (2008)	Assessment of various risks associated to off shoring process	Supply risk, Product related , partner related, environment related	Methodology based on integration of AHP and Action Research
	R R.Levary et al(2008)	Risk consideration in Supplier selection	Environmental side, Country risk such as political situation of country, natural or manmade caused disasters and currency convertibility risks	AHP
	Wu et al.(2006)	Supply risk management framework	Supply risk Internal controllable, Internal partially controallable, Internal uncontrollable, external controllable, External partially controallable, External uncontrollable	AHP, Prototype computer implementation system
	F.T.S. Chan et al(2007)	Supplier Selection	Supply risk, environmental risk, Geographical location, political stability, Economy, Terrorism	AHP was combined with fuzzy logic
	Kull et al(2008)	Supplier risk reduction	Delivery failure, Cost failure, Quality failure, Flexibility failure,general confidence failure	integrated AHP and goal programming tools
	R. Desbordes et al (2007)	Comparison of RO and SCRM to know the impact of uncertainties on US FDI	Environmental risk, Political uncertainty, Macro economic uncertainty	Real option approach, SCRM approach
	Ramesh et al 2010	Identification of the barriers of SCC in the Indian apparel retail industry	Supply risk, sourcing risk, Lack of trust among the supply chain partners, . Lack of training for new mind set and skills.. Lack of collaborative and strategic planning.. Lack of top management commitment. . Lack of supply chain vision/understanding. . Disparity in technological capability among partners.. Inadequate information sharing. . Unwillingness to share risk and reward. . Inconsistent and inadequate performance metrics.	hierarchy-based model using interpretive structural modeling
	Bindu, R. S. et al 2010	Vendor selection	Supply risk, Reliability risk	AHP, concept of alternatives functionality graph
	Ordoobadi, S. M. (2010	Supplier selection	Supplier selection risks	Hybrid approach based on AHP and tguchi loss function
	Xia, D. et al 2010	Optimal selection of SC risk management strategies	Risk involve in decision making, internal risks	proposed a decision-making model based on ANP
	Haleh, et al 2010	Orders allocation to suppliers	Supply risk, Uncertain information	fuzzy multi-objective linear programming model

4.3.1.4 Mathematical Modeling approaches [Single period multi stage model]

Financial default or bankruptcy of supplier is a major risk growing now days. To protect them from supply disruptions, firms are usually safeguarding by installing redundancy in backup supply. Multi supplier strategy is most used strategy by firms (Tang et al 2006) against supplier default risks

(Babich et al 2006) studied the effect of supplier default and proposed a model for a two-echelon supply chain with competing risky suppliers and a single manufacturer. Author investigated how the supplier default risk and default co-dependence affect manufacturer procurement and production decisions, supplier pricing decisions, firms profits, and the deferment option value and how the introduction of the deferment option alters supplier competition.

4.3.1.5 Mathematical Modeling approaches [Mixed Integer Linear Programming model]

(Pishavee et al 2010) proposes a hi-objective mixed integer programming model to deal with uncertainty and risks in a closed loop supply chain network. The proposed model integrates the network design decisions in both forward and reverse supply chain networks, and also incorporates the strategic network design decisions along with tactical material flow ones to avoid the sub-optimality's led from separated design in both parts. (Georgiadis et al 2011) formulated a mixed-integer linear programming program (MILP) model for a supply chain network, comprising multiproduct production facilities with shared production resources, warehouses, distribution centers and customer zones, in which demands products are both uncertain and time varying.

(Miguel Laínez, J.2009) recommend that supply chain (SC) and product development activities should be coordinated and synchronized to avoid from different supply chain risks. In their multi stage mixed integer linear programming proposed model, not only variables represent Sc design planning and R&D decision but endogenous uncertainty associated with product outcome is also included. This is done through adding a risk constraint which allows finding optimal solution with accepted risk level.

(Chandra A. Poojari 2008) formulated a two stage stochastic Integer programming model for the resource allocation on various strategic decisions such as site locations, choices of productions ,packing and distribution lines etc.

(Fengqi You 2009) developed a two-stage stochastic linear programming model that takes into account the production and inventory levels, transportation modes, times of shipments, and customer service levels under demand and freight late uncertainty.

(Deniz, E. 2008) studied supply chain optimization with the help of stochastic programming and mixed integer programming approach with the objective of net present value of the cash flow along with consideration of uncertainties associated with demand ,market price , supply and procurement costs.

(J.K.Deane et al 2009-b) developed a generalize mathematical model that quantifies IT security risk in the supply chain. The objective functions are minimizing upstream risk, minimizing downstream risk, and minimizing global (supply chain) risk. The author further highlights other decisions regarding IT security .i.e how to develop curves for each of the above scenarios that indicate when extra funds should be spent on security, which security controls should be implemented, and when subsidies among partners are beneficial

(Wang et al 2009) argued that facility location is considered to be very crucial stage in supply chain design. In this article, Authors developed an integer programming approach to solve the issue of choosing optimal plant from many potential plants.

(J.K.Deane et al 2009-a) developed a tool based on multi criteria optimization framework which will enable the user to gain a better understanding of how the consideration of each of risk measures will affect the recommended solution/supply base.

(Ben-Tal et al 2010) proposes a methodology to generate a robust logistics plan that can mitigate demand uncertainty in humanitarian relief supply chains. Author also applied robust optimization (RO) for dynamically assigning emergency response and evacuation traffic flow problems with time dependent demand uncertainty.

(Dillon, R et al 2010) proposed a framework for a supply-risk network to capture potential disruptions by formulating a Global Supply Chain disruption-risk model that allows for organizations within the supply chain to strategically plan for the sourcing (i.e., procurement) and flow of goods throughout the supply chain in a manner that directly incorporates the risk of disruption. The GSC disruption-risk model is formulated as a two-stage stochastic integer programming problem with fixed recourse.

(Sabio et al 2010) presented a decision-support tool to address the strategic planning of hydrogen supply chains for vehicle use under uncertainty in the operating costs. Author determined the optimal design of the production - distribution network capable of fulfilling a predefined hydrogen demand with the help of multi-scenario mixed-integer linear problem.
(Pan, F et al 2010) considers a supply chain design problem for a new market opportunity with uncertain demand in an agile manufacturing setting. The author considers the integrated optimization of logistics and production costs associated with the supply chain members.
(Peidro, D. et al 2010) model supply chain (SC) uncertainties both demand and supply by fuzzy sets and develops a fuzzy linear programming model for tactical supply chain planning in a multi-echelon, multi-product, multi-level, multi-period supply chain network.

4.3.1.6 Mathematical Modeling approaches [Multi objective Programming model]

(D.D. Wu et al. 2010) proposed a mathematical model for suppliers' selection by using a fuzzy multi objective programming approach. Risk factors considered are both qualitative and quantitative such as cost, quality, logistics, environmental factors and vendor rating etc. The proposed model is implemented to a three level supply chain. The author concluded that probability of certain supplier is effected when qualitative criteria is used.
(Wu et al 2008) compared three risk evaluation models based on chance constraint programming, data envelopment analysis and multi objective programming in a three level supply chain. The proposed approach by authors not only help to evaluate and improve supplier selection decisions but provide a trade off analysis among expected costs, quality acceptance level and on time delivery distribution. The author compared above three models with results generated by simulation

4.3.1.7 Mathematical Modeling approaches[Non Linear Programming model]

Most of the time, the objective functions are considered to be minimizations of risks and maximization of profit when developing mathematical models specifically in goal programming, linear programming and non linear programming. (Anna Nagurney 2006) formulated a NLP model that represents a global supply chain of retailers, manufacturer and distributors with the objective of optimizing their behavior for decision making , maximization of profit a and minimization of risks.

(Sarkar et al 2009) proposed a mathematical model for choosing the optimal number of suppliers under supply risk disruptions. In Model formulation, authors considered super, semi and unique events that lead to supply risk. Business to Business market exchange B2Bs are online markets where buyers and sellers trade products either in cash (the ‘‘spot’’ market) or via derivate instruments such as options, futures, or forward contracts. (P. Aggarwal 2007) shows that how B2Bs and risk management tools integrated together to mitigate various risks in the supply chain. Author modeled a scenario where a manager has two procurement channels: the preferred supplier with an exogenously determined contract price and the B2B with an uncertain spot price. The manager can, however, buy forward contracts (for a cost) to mitigate price volatility. Forwards are customized contracts in which the manager agrees to purchase the product from a seller at a future time for a pre-determined price (see Hull, 2000). Facing uncertain demand, their proposed model helps managers decide on the optimal ‘‘portfolio’’ of procurement options, i.e., the quantity to buy from the preferred supplier, number of forward contracts to write, and when necessary, use the spot market to satisfy demand.

(J.M. Cruz et al 2008) develops a framework for the analysis of the optimal levels of corporate social responsibility (CSR) activities in a multi period supply chain network consisting of manufacturers, retailers, and consumers. Manufacturers and retailers determine their production quantities, transaction quantities, and the amount of social responsibility activities they want to pursue that maximize net return, minimize emission, and minimize risk over the planning horizon. The author investigate the interplay of the heterogeneous decision-makers and compute the equilibrium pattern of product outputs, transactions, prices, and levels of social responsibility activities.

(Jose M. Cruz et al 2006) applied the concept of financial engineering to the process of supply chain risk management through the inclusion of relationship levels. The author models the multi criteria decision-making behavior of the various decision-makers in a supply chain network, which includes the maximization of profit, the minimization of risk, and the maximization of relationship values through the inclusion of the social network, in the presence of both business-to-business (B2B) and business-to-consumer (B2C) transactions.

4.3.1.8 Mathematical Modeling approaches [Stochastic Programming model]

(M. Goh et al. 2007) presented a stochastic model where he considered various types of risks such as supply risks, demand risks, exchange risks and disruptions in global supply chain

network. Authors proposed an algorithm that maximize the profits while minimizes the risks using Moreau-Yosida regularization a famous and well-developed technique found in stochastic programming to provide a solution methodology and to design an algorithm for obtaining the optimal solution to the original supply chain network problem with profit maximization and risk minimization objectives. With this proposed algorithm , non smooth functions can be smooth for rapid convergence, and can therefore be used to solve some practical supply chain network problems.

In today's competitive market, companies are heavily relying with their suppliers on order replenishments. Not all the time, the suppliers appear to be reliable especially those from different countries. To handle supply disruptions, (Eleftherios et al 2010) propose a single period stochastic inventory decision-making model that can be used for capturing the trade-off between inventory policies and disruption risks for an unreliable dual sourcing supply network for both the capacitated and un capacitated cases.

The uncertainty in optimization models for the oil and gas supply chain has been noted by several academic studies conducted in the past several years. Despite the many studies of optimization problems under uncertainty in the oil industry, few consider risk management measures to solve planning problems in the oil industry, none manage the risk in the portfolio optimization problem in the oil supply chain. To fill this gap (Maria C. Carneiro 2010) included financial risk management in the integrated oil supply chain planning under uncertainty, using the framework of two-stage stochastic programming and applying the conditional value-at-risk (CVaR) measure to design an optimal portfolio. Author proposed a model that takes into account the entire oil supply chain, from exploration fields to distribution centers, and allows for the analysis of investments in both refineries and logistical infrastructure.

Table 9: Summary of Mixed Integer Linear Programming Models & Hybrid Intelligent Systems approaches

Mathematical Programming(Mixed Integer Linear Programming Models)	Pishavee et al 2010	uncertainty and risks in a closed loop supply chain network	Uncertain and imprecise parameters	hi-objective mixed integer programming model
	Georgiadis et al 2011	time varying demand uncertainty	Uncertain demand	mixed-integer linear programming program (MILP) model
	Miguel Laínez, J.(2009)	SC design with risk consideration	Financial risk	stage mixed integer linear programming
	Chandra A. Poojari(2008)	investigated a strategic capacity planning problem having uncertain demand	Uncertain demand	two-stage Stochastic Integer Programming
	Fengqi You(2009)	tactical planning of a uncertain global multi-product chemical supply chain	Demand uncertainty, freight late uncertainty, downside risk,financial risk	developed a two-stage stochastic linear programming model
	Deniz, E.(2008)	Maximizing present value of the cash flow along with consideration of uncertainties	uncertainty associated with demand, market price, supply and procurement costs	stochastic programming and mixed integer programming approach
	J.K.Deane et al(2009-b)	Quantification of IT security risk	IT security risk, upstream risk, downstream risk, and global (supply chain) risk	Generalized Mathematical model
	Wang et al(2009)	Optimal plant selection	Facility location problem, internal risk	an integer programming approach
	J.K.Deane et al(2009-a)	Supplier selection	Environmental risk and density risk	a multi-criteria optimization framework
	Ben-Tal et al 2010	demand uncertainty in humanitarian relief supply chains	Demand risk	Robust optimization
	Dillon, R et al 2010	Optimal supply network with minimum disruption	Environmental risk	a two-stage stochastic integer programming problem
	Sabio et al 2010	Uncertain operating cost	Cost risk, internal risk	a decision-support tool based on mixed integer linear programming
	Pan, F et al 2010	Supply chain design under agile manufacturing	Uncertain demand	Robust optimization program
	Peidro, D. et al 2010	Tactical supply chain planning g	Demand risk, process risk and supply risk	a fuzzy linear programming model
	D.D. Wu et al.(2010)	Supplier selection	Qualitative and quantitative risk such as cost, quality, logistics, environmental factors and vendor rating	a fuzzy multi objective programming approach.
	Wu et al (2008)	Supplier selection decision	Supply risk	compared three risk evaluation models based on chance constraint programming, data envelopment analysis and multi objective programming

Mathematical Programming (Mixed Integer, Linear, NLP and Stochastic Programming Models)	Anna Nagurney(2006)	Optimization of behavior for decision making , maximization of profit a and minimization of risks	Supply side rik, demand side risk	NLP model
	Sarkar et al(2009)	Supplier selection	Supply risk [Super events, semi super event and unique events]	We depict the model in a decision tree-like structure and forward a tabular method of solution
	. Aggarwal(2007)	Selection of contract type with supplier	Supply risk, risk associated to wrong contract	Buisness to Buisness Exchange with risk management tools
	J.M. Cruz et al(2008)	analysis of the optimal levels of corporate social responsibility (CSR) activities	Risk associated to decision making for optimal allocation	Variational inequality formulation
	Jose M. Cruz et al (2006)	multi criteria decision-making behavior of the various decision-makers in a supply chain	Risk associated to decision making for optimal allocation	Variational inequality formulation
	M. Goh et al.(2007)	maximize the profits while minimizes the risks	supply risks, demand risks, exchange risks and disruptions	presented a stochastic model using Moreau-Yosida regularization a famous and well-developed technique
	Eleftherios et al(2010)	Supply side decision making with unreliable dual sourcing supply network	Supply risk	a single period stochastic inventory decision-making model
	Maria C. Carneiro(2010)	consider risk management measures to solve planning problems in the oil industry	Internal risk, uncertain demand, oil price, environmental risk	framework of two-stage stochastic programming and applying the conditional value-at-risk (CVaR) measure to design an optimal portfolio
	A.Azaron et al.(2008)	Design of supply chain with risk consideration	Uncertainity in Demands, supplies, processing, transportation, shortage and capacity expansion costs	multi-objective stochastic programming approach
Hybrid Intelleigence/ Systems Dynamics approach	Ganguly, K. K. (2009)	Risk assessment	Supply side risk	pattern matching approach of fuzzy set theory
	Ma, H.(2007)	Risk evaluation	Supply chain default risk	Combination of fuzzy sets with influence diagram theory
	Zhang,F.(2006)	Risk prediction	Supply side risk	linear dynamic system is developed that integrate generic Gaussian noise assumptions with principal component analysis
	Kumar et al 2010	risk identification and making optimal decision regarding the inter-echelon quantity flow	Operational risk, risk embedded in Cost	a multi-echelon global supply chain model
	D.Bogataj et al(2007)	Risk measurement	Supply risk, process, demand, control, Environmental Risk,	A model based on input output analysis and laplace transforms
	Sami Kara(2008)	establish inter and intra-relationships between various risk factors in the entire enhanced network of engineering projects	Logistics risks, complex logistics network	A system dynamics approach

(A.Azaron et al. 2008) developed a multi-objective stochastic programming approach for supply chain design under uncertainty. Demands, supplies, processing, transportation, shortage and capacity expansion costs are all considered as the uncertain parameters. Besides that, two additional objective functions are added into the traditional comprehensive supply chain design problem.

4.3.1.9 SPC approaches/ Statistical probabilistic models

Risk management in a supply chain also requires certain tradeoffs, e.g. dependence on single supplier may be risky but the risks to intellectual property when working with single supplier are far less. Risks cannot be completely eliminated from supply chains but strategies can be developed to manage these risks if the dynamics between the variables related to risks in a supply chain are understood. The use of graph theory is well documented in literature and can be applied to model and analyze various types of systems (Faisal et al 2006-a) developed a model that maps different types of supply chain on two dimensions, Customer sensitivity and risk alleviation competency dimensions. For risk alleviation competency and customer sensitivity evaluation of supply chains graph theoretic approach would be applied. By using this approach we can transform the risk alleviation competency and customer sensitivity into single numerical values.

This would help to compare and map supply chains on these two dimensions. Based on above dimensions, suitable supply chain strategies can be selected.

(Neureuther, B. D. 2009) develops a risk assessment index, to assess the vulnerability of different supply chain structures. Author concluded that there exists significant trade-offs between the number of suppliers in the supplier base, product diversification, supply chain coordination, and supply chain efficiency that must be examined for a supply chain to remain competitive in a highly risky, vulnerable environment.

(A.J. Ruiz- et al 2007) proposed a model based on decision tree approach to determine optimal no of suppliers during the presence of supplier failure risks. Author concluded that sole sourcing is appropriate strategy to obtain lower cost when reliability of all suppliers is high. In less reliable environment, additional suppliers are needed to remain in lower cost situation.

(Faisal, M. N. 2009) also proposed an approach that models the dimensions of risks susceptibility and risk mitigation in a supply chain. This graph-theoretic approach is to

investigate the risk in the context of supply chain and benchmark supply chain on risk dimensions. The approach also transforms the qualitative dimensions of risks into quantitative terms.

(Faisal, M. N 2007-b) proposed a framework based on graph theory and matrix methods which models variables associated with risk mitigation environment and their interdependencies.

(Lee, T. Y. S. 2008) proposed mean-variance approach to determine the optimal set of suppliers in the presence of supplier failure risks. In their model, the author considered two objectives cost minimization and satisfaction of service level.

(C.S. Tapiero et al 2007) provided a quantitative model that deals with quality control in supply chain of one supplier and one producer based on Neyman pearson statistical risk framework with economic considerations.

Recently, (Lockamy, A 2010) uses Bayesian network to create risk profile for a given supplier and assess various internal and external risk probabilities and revenue associated to these risks. Author shows that methodology can be used for outsourcing decision with either current or prospective suppliers. Without accurate and prompt forecasts of upstream supplies, it is difficult for a manufacturer to manage the disruption risks in an optimal manner. Another study that helps to determine how to make optimal ordering decisions when its supplier experiences disruptions over time is that of (Chen et al 2010). Author proposed a Bayesian model to dynamically update the knowledge of supply risks, which uses Dirichlet prior distributions to achieve mathematical tractability in Bayesian updating. Optimal-sourcing strategies are studied under this framework. The author examined various outsourcing strategies with the help of Bayesian model. Authors concluded that sourcing decisions based on Bayesian information are more effective than based on static information

(Jiang et al 2009) identified various root causes of job dissatisfaction leading to labor turnover in China those results in poor quality, low productivity and unfilled orders, such as meager Human Resource Management practices, poor Production and Operation Management activities, and unfair buyer behaviors. Author also provided managerial implications that may assist managers in dealing with labor-related supply chain risks. According to author, suppliers can solve these problems by adopting new enterprise level HRM practices such as performance based compensation, training and emphasizing commitment and implement POM practices. International buyers can cooperate with suppliers to improve labor conditions by giving financial award to those reduce employee

turnover ,educating the suppliers about advantages of stable work force and its impact on supply chain. Government can also play role on this by encouraging local companies to consider employee retention. (S.M. Wagner et al 2009-a) proposed a quantitative model to analyze supply chain vulnerabilities using graph theory approach and studied the interdependence of vulnerabilities' drivers. Authors defined supply chain vulnerability as the results of certain characteristics. Three main drivers of vulnerabilities are classified into supply side, demand side and supply chain structure. Supply chain vulnerability can be measured at entire economic level, industry, entire supply chain and at focal firm Interdependencies between drivers are quantified by graph. (faisal et al 2007-a) argued that One of the main aspects of Supply chain management is the information flow between different partners. Effective and efficient information flow reduces the transaction costs involved in supply chain. Supply chain management is facing risks now days such as supplier risks or catastrophic risks etc. Risks involved in information must also be considered as serious issue as the whole supply chain depends a lot on information management. Author presented various recommendations such as information sharing among SC partners, support to partners and incentive alignment etc. These enablers are required to understand fully their inter relationship in order to mitigate information risks. Author did not only identify key information risks but also proposed a conceptual framework to quantify these risks

In today's fast and competitive business environment, one of important decisions managers have to make is supplier's selection. The traditional approach of choosing a supplier i.e lowest bid price suppliers is no longer acceptable under such uncertain environment. Liang-(Chuan et al 2009) proposed a supplier selection model under economic standpoint by using switching option approach which helps managers to choose suppliers under uncertainty.

(Moonis, M et al 2010) studied and identify the knowledge and data required to develop fully a risk assessment for a hydrogen delivery and storage infrastructure. In risk assessment methodology top-down HAZID brainstorming, consequence modeling using commercially available software, and use of a risk matrix were used.

4.3.1.10 Others

It is well known that collaboration among supply chain partners, enabled by communication networks, offers significant operational benefits to the supply chain. However, such collaboration also increases the information security risk within a supply chain

Table 10: summary of Statistical/ SPC Models

Statistics/SPC Models	Faisal et al(2006-a)	Mapping supply chain on risk and customer sensitivity dimensions	Customer sensitivity, unpredictable demand, demand side	A model that maps supply chain on two dimensions, Customer sensitivity and risk alleviation competency dimensions
	Neureuther, B. D.(2009)	Risk assessment in supply side	Supply risk, late product delivery	develops a risk assessment index
	A.J. Ruiz- et al(2007)	to determine optimal no of suppliers during the presence of supplier failure risks	Supply risk	proposed a model based on decision tree approach
	Faisal, M. N. (2009)	models the dimensions of risks susceptibility and risk mitigation in a supply chain.	Consider general supply chain risk	graph-theoretic approach
	Faisal, M. N(2007-b)	models variables associated with risk mitigation environment and their interdependencies.	Environmental side risk	Graph theory and matrix approach
	Lee, T. Y. S. (2008)	determine the optimal set of suppliers in the presence of supplier failure risks. In	Supply risk	mean-variance approach
	C.S. Tapiero et al(2007)	Quality control in SCM	Quality risk	Quality model based on Neyman pearson statistical risk framework with economic considerations.
	Lockamy, A(2010)	Outsourcing risk assessment	Supply risk	Used Bayesian network to create risk profile
	Chen et al(2010).	determine how to make optimal ordering decisions when supplier experiences disruptions over time	Environmental risk, supply risk	Baysian model which uses Dirichlet prior distributions
	Jiang et al (2009)	root causes of job dissatisfaction	Cost risks, operational risks and reputation risks	Factor analysis, regression analysis
	S.M. Wagner et al(2009-a)	Risk analyze and interdependencies	Demand side, supply side and supply chain structure	graph theory approach
	faisal et al(2007-a)	Identification of information risk	information security/breakdown risks; . forecast risks; . intellectual property rights risks; and . IT/IS outsourcing risks.	risk index and the hierarchy-based model
	Chuan et al(2009)	Supplier under uncertainty	Supply risk	switching option approach
	Moonis, M et al 2010	Risk assessment in hydrogen supply chain	Environmental risk	top-down HAZID brainstorming, consequence and frequency modeling using commercially available software, rik matrix

(Bandyopadhyay 2010) studied such important risk factor, their different relationship types ,degrees and proposed strategies to mitigate these risks.

Recent trends in outsourcing extend a contract manufacturer's (CM's) responsibility to several functional areas, such as research and development and design in addition to manufacturing. This trend enables an original equipment manufacturer (OEM) to focus on sales and pricing of its product. However, increasing

CM responsibilities also suggest that the OEM's product quality is mainly determined by its CM. (Kaya and Özer 2009) studied various concepts of quality risks in Outsourcing relationship between Contract Manufacturer and original equipment manufacturer. Authors showed impact of different strategies on relationship and results, such as impact of OEM's pricing strategy on quality etc.

While the suppliers play an important role in achieving the entire supply chain excellence, they also represent one major source of uncertainty and disruption. Many companies have experienced supply disruptions during the series of tragic disasters that have occurred over the past few years, such as fire in Philips's plant. (Jing Hou et al 2009) analyzed the impact of backup supplier in case of supply risk. The author proposed a quantitative model that would help to determine the optimal order quantity assigned to back up suppliers when supply risk consider. Base on the model, author proposed various recommendations i.e under what circumstances; buyer should order backup supplier and how much order should be allocated etc.

(Tomlin 2009) analyzed various disruption management strategies and linked them to different supply chain risks. Author concluded that when supply risks are high, contingent sourcing is more appropriate to implement rather than supplier diversification. On the other hand, when demand risk is high, diversification is more proffered. Readers are referred to paper for other strategies.

(J. Li et al 2010) studied various sourcing strategies in retailer's perception when dealing with multiple suppliers and derived a model for the selection of optimal strategy.

(Wei&Dong et al 2009) presented input-output model (IIM) for the risk assessment in a complex supply chain network. In this approach, inoperability and economic losses are calculated at each node (supply chain partners) and prioritized them according to potential impacts and risks mitigating or managing strategies are implemented. The IIM model is further validated for its effectiveness with the help of Monte Carlo simulation. Furthermore it is used for checking the effectiveness of mitigating strategies.

(H. Yu et al 2009) modeled the impact of supply risks on the decision of outsourcing by considering single sourcing and dual sourcing in a two stage supply chain. The authors also identify the critical factors that lead to final decisions for supplier selections.

Various authors have showed that flexibility plays significant role in supply chain resilience. However, the issue that how much flexibility is needed is still not addressed very well. (Tang et al 2008) answered this fundamental question that how much flexibility a company need by presenting 5 stylized models. By considering 5 different stylized models taken from literature review, author has shown analytically that a firm does not need to invest in a high degree of flexibility to mitigate supply, process, and demand risks; most of the benefits are obtained at low levels of flexibility.

(Volodymyr Babich 2007) addresses the problems faced by a retailer who deals with multiple competing suppliers who may default on their obligations to deliver order quantities at the end of a given production lead time. Author tried to answer various issues of supplier selection, pricing and ordering policies among firms.

In a supply chain, the allocation of inventory risk varies in different situations. Some firms may avoid taking the risk by transferring it to the others. The supplier may sell the inventory to the retailer by enforcing preorder so that the retailer needs to procure before the production and carry the inventory during the selling season. This phenomenon is also known as preorder mode. Sometime the supplier may also offer consignment, where the retailer sells the product for the supplier for some commission which is known as consignment mode. A supply chain may also be operated under a combination of the above two modes so that the risk is shared among the firms called combination mode. Therefore, which supply chain mode shall be adopted under a given environment deserves a close examination. Author studied the impact of financial constraint on the efficiency of the supply chain modes.

Many authors defined two main supply risks known as disruptions risks and delays risks (also view as recurrent risk). (Sunil Chopra 2007) focuses on the importance of decoupling recurrent supply risk and disruption risk when planning appropriate mitigation strategies. The author show that bundling the two uncertainties leads a manager to underutilize a reliable source while over utilizing a cheaper but less reliable supplier.

(Brian Tomlin 2006) also studied a single-product setting in which a firm deal with two suppliers, one that is unreliable and another that is reliable but more expensive. On the bases of their proposed model, author presented various strategies and considerations when dealing with reliable and unreliable suppliers.

Supply chain management assumes a major role in the logistics activities associated with responding to disasters caused by hazards such as major hurricanes, earthquakes, and acts of war and terrorism. In particular, the logistics function aims to ensure that the right supplies are available at the right places, at the right times, and in the right quantities so that initial response disaster relief operations can be implemented quickly and effectively. (Emmett J. Lodree 2008) addresses an emergency response inventory planning problem that is relevant to manufacturing, service, not-for-profit, and government organizations who provide supplies, equipment, and manpower to support disaster relief operations.

(C.-Y. Tsai et al 2008) models the supply chain related cash flow risks for a business entity measured by the standard deviations of cash inflows, outflows, and net flows of each period in a planning horizon. The goal is to provide an insightful look on how common practices that intend to improve the Cash Conversion Cycle (CCC), e.g., offering early payment discounts, may contribute to cash flow risks.

(Chun-Ta Lin et al 2009) focuses on the treatment of hedging operational risks in the coordinated replenishment and shipment for distribution systems. The author propose a hedge-based coordinated inventory replenishment and shipment (HORS) methodology for flexibly making inventory hedging and optimal routing assignment decisions as well as coordinating replenishment and shipment policies.

(Rijgersberg et al 2010) simulated and modeled food supply chain using quantitative microbial risk assessment (QMRA). Furthermore, author has considered food safety risk by modeling the underlying distribution.

(Chen, F. Y. et al 2010) analyzed a manufacturer-retailer supply chain for a seasonal product whose demand is weather sensitive and examined how a manufacturer can structure a weather-linked rebate to improve his expected profit. The proposed class of rebate contracts offers several advantages over many other contract structures, including no required verification of leftover inventory and/or markdown amounts, and no adverse effect on sales effort by the retailer.

(Handfield et al 2010) developed a (Q, r) model based on fuzzy-set representations of various sources of uncertainty in the supply chain. Sources of risk and uncertainty in our model include demand, lead time, supplier yield, and penalty cost.

(Liu, Z. et al 2010) developed a variational inequality model that considers firms' decision-making regarding pricing, offshore outsourcing, transportation, and in-house production under competition and foreign exchange uncertainty. Author studied the impacts of foreign

exchange risk and competition intensity on supply chain companies who are involved in offshore-outsourcing activities.

(Wu, Y. et al 2010) proposes a discrete time model to characterize the unreliable production capacity in serial supply chain networks. Author concluded that the performance of the supply chain network suffers more from the downstream-stage unreliability than the upstream-stage unreliability.

(Wang, Y et al 2010) explored a model in which a firm can source from multiple suppliers and/or exert effort to improve supplier reliability. For both random capacity and random yield types of supply uncertainty, author propose a model of process improvement in which improvement efforts (if successful) increase supplier reliability in the sense that the delivered quantity (for any given order quantity) is stochastically larger after improvement.

(Wang, H.-F et al 2010) proposed a generalized model where the uncertainty is expressed by fuzzy numbers.

(Xiao, T. et al 2010) investigated coordination of a supply chain consisting of one manufacturer and one retailer facing consumer return. With developing modeling framework, author integrates consumer returns policy and manufacturer buyback policy and positive effect of refund amount on demand and its negative effect on the probability that consumers keep the products. Furthermore, author design a buyback/markdown money contract to coordinate the supply chain under partial refund policy and find that the refund amount plays an important role in the decisions and profitability of the players.

(Xiaoyan et al 2010) studied the methods for reducing the probability of bankruptcy through supply chain coordination. Based on the developed multi agent simulation model for a simple three-echelon supply chain, the effects of coordination mechanisms, such as information sharing (INS) and vendor-managed inventory (VMI), on reducing the occurrence of bankruptcy at each stage of the supply chain were examined.

(Lee, J. et al 2010) examined coordination problems and corresponding incentive mechanisms between a manufacturer and a retailer for jointly investing in a new technology that has the potential to improve the efficiency and security of the supply chain.

(Talluri, S. et 2010) presents a set of optimization models that address the issue of optimally allocate investment dollars among multiple suppliers to minimizes risk while maintaining acceptable level of return.

(Sting, F. J. et al 2010) analyzed different contractual practices for firms when they perform global sourcing. such as how firms should contract with backup suppliers, inducing the latter to install responsive capacity. Author concluded that supply options are appropriate to achieve sourcing channel coordination under forced compliance, whereas any firm commitment contract imposes a deadweight loss on the system. Whereas price-only contracts are unable to coordinate the sourcing channel under voluntary compliance, utilization-dependent price-only contracts are. Under the former contract, a price-focused strategy on the part of the manufacturer turns out to diminish the system's service level and possibly has negative implications on installed backup capacity, and not least on the manufacturer's profit.

4.3.1.11 Operation Research/Non Parametric tool

(Azadeh et al 2010) proposed three types of vendor selection models in supply chains and presents a decision making scheme for choosing appropriate method for supplier selection under certainty, uncertainty and probabilistic conditions. These models are, Data Envelopment Analysis (DEA), Fuzzy Data Envelopment Analysis (FDEA), and Chance Constraint Data Envelopment Analysis (CCDEA). In this study, we presented a decision making flowchart to choose from DEA, FDEA and CCDEA for selection of best supplier under certainty, uncertainty and probabilistic conditions. This is the first study to a present a flexible deterministic, stochastic and fuzzy approach for supply chain risk and vendor selection.

4.3.2 SIMULATION

(M.C. Wilson et al 2007) investigates the effect of a transportation disruption on supply chain performance using system dynamics simulation, comparing a traditional supply chain and a vendor managed inventory system (VMI) when a transportation disruption occurs between 2 echelons in a 5-echelon supply chain. The author concluded that the greatest impact occurs when transportation is disrupted between the tier 1 supplier and warehouse. In the traditional structure the retailer, warehouse, and tier 1 supplier experience the greatest inventory fluctuations and the highest goods in transit to their facilities. These impacts are less severe for the VMI structure, although unfilled orders are approximately the same for each.

(Yu,H. 2007) analyzed two different distribution function of random variable used to express supply disruption with simulation approach and provide various managerial implications for

mitigation. Author analyzed the fact how coordination mechanism influenced and effected when prone to disruptions.

(Miller, H. E. 2008) also simulated a hypothetical three tier supply chain exposed to natural disaster and studied various scenarios including correlation between different nodes, effectiveness of disaster recovery plan and dual sourcing etc.

With the help of simulation, (Cigolini, R 2006) proposed a methodology that evaluate the collaboration level between logistic network within a supply chain. Author also evaluated the methodology with the help of case study in grocery market.

(Klimov, R. 2008) investigates various risks discussed earlier in the literature and then simulation based risk evaluation approached is used for evaluation.

(Denis R. Towill 2008) studied supply chain risk resulting from bull whip effect if use order up to policy and proposed specific recommendations. The results are validated with the help of simulation.

(Abdelkafi, C. 2009) use Bayesian approach for the improvement of forecasting of medication requirements by optimization supply chain through balancing the various costs against the out of stock risks etc.

(Thomas et al 2008) analyzed the impact of 2^{nd} tier supplier failure in supply chain management with the help of simulation. Authors proposed 3 main hypotheses that excess inventory at focal organization, at distributor and at supply chain decrease the supply risk and verified their validity through simulation. Authors concluded that excess inventory or increase inventory in decentralized supply chain increases the possibility of supplier failures instead of decreasing it. (D.Neiger et al 2009) proposed methodology for risk identification in a supply chain based on value focused process engineering. In this methodology, all activities related to organizations or systems or network are identified and then risks related to these activities are observed.

(Colicchia et al 2010) identifies a set of approaches for managing global sourcing risks in order to enhance supply chain resilience. Furthermore, author developed a simulation-based framework for assessing the effectiveness of the proposed approaches

Table 11: Summary of Optimization & Simulation Models

Optimization Models	Kaya and Özer(2009)	quality risks in Outsourcing relationship between Contract Manufacturer and original equipment manufacturer	Quality risk supply risk	a three-stage decision model based on optimization
	Jing Hou et al (2009)	analyzed the impact of backup supplier in case of supply risk	Supply risk	quantitative model based on optimization theory
	Tomlin(2009)	Analyze Disruption management strategies due to supply risk	Supply risk	Decision making optimization model
	J. Li et al(2010)	Supplier selection	Supply risk	derived a model for the selection of optimal strategy base on optimization
	Wei&Dong et al(2009)	Assessment of disruption on supply chain	Environmental risk	Input output model, Monte carlo simulation
	H. Yu et al(2009)	Impact of risks on outsourcing decision	Supply risk, environment risk	Two stage supply chain optimization model
	Tang et al(2008)	how much flexibility a company need	Supply risk, Process risk, Demand risk, Intellectual property risk, Behavioral risk and political/social risk	Presented 5 stylized optimization models
	Volodymyr Babich(2007)	Effect of supplier default risk on supply chain	Supplier default risk	Single period supply chain model based on optimization theory
	Volodymyr Babich(2006)	Effect of supplier default risk on supply chain	Supplier default risk	Optimization model
	Sunil Chopra (2007)	Recurrent supply risk and disruption risk	Supply risk, environmental risk	Optimization model
	Brian Tomlin(2006)	dealing with reliable and unreliable suppliers.	Supply risk	On the bases of proposed optimization model, author presented various strategies and considerations
	Emmett J. Lodree (2008)	emergency response inventory planning problem	Demand risk , environmental risk, disruption risk	Insurance Risk Management framework based on 4 different variations of newsvendor problem
	C.-Y. Tsai et al(2008)	models the supply chain related cash flow risks for a business entity	asset risk, relationship risk and competence risk	Autoregression model, simulation experiment
	Chun-Ta Lin et al(2009)	treatment of hedging operational risks in the coordinated replenishment and shipment for distribution systems	Operational risk	The forward option pricing model with the generalized autoregressive conditional heteroskedasticity (GARCH) model for stochastic demand forecasting
	Rijgersberg et al 2010	Assessment of food safety risks	Food safety risk, logistic risks	quantitative microbial risk assessment (QMRA) based on discrete event modeling, Simulation
	Chen, F. Y. et al2010	Improve profitability by structuring weather linked rebate	Weather related demand uncertainty	Optimization model
	Handfield et al 2010	Analysis of inventory policies in	Uncertainties in demand, lead time, supplier	a (Q, r) model based on fuzzy-set

		uncertain supply chain	yield, and penalty cost.	
Optimization Models	Liu, Z. et al 2010	firms' decision-making regarding pricing, offshore outsourcing, transportation, and in-house production under uncertainties	Exchange rate risk, environmental risk, competition risk	developed a variational inequality model
	Wu, Y. et al 2010	Modeling production capacity in serial supply chain networks with uncertainty	Unreliable production uncertainty	a discrete time model
	Wang, Y et al 2010	improve supplier reliability	Supply risk	propose a newsvendor model of process improvement
	Wang, H.-F et al 2010	Uncertainty in SCM	Global warming, environmental risk	Interval programming mode, fuzzy numbers, mean square imprecision index
	Xiao, T. et al 2010	investigated coordination of a supply chain consisting of one manufacturer and one retailer facing	Demand risk, demand uncertainty	Developing modeling framework and design a buy back money contract based on game theory
	Xiaoyan et al 2010	methods for reducing the probability of bankruptcy	Financial risk, bankruptcy	developed multi agent simulation model
	Lee, J. et al 2010	examined coordination problems and corresponding incentive mechanisms between a manufacturer and a retailer	Coordination problems, security breaches, behavioral uncertainty, environmental risk	Optimization model
	Talluri, S. et 2010	issue of optimally allocation of investment dollars among multiple suppliers	Supply risk	Quadratic programming model
	Sting, F. J. et al 2010	Contractual practices while outsourcing	Supply risk, demand risk, supply risk	Analyze various contracts through optimization models
	Azadeh et al 2010	supplier selection	Supply uncertainty, supply risk	Data Envelopment Analysis (DEA), Fuzzy Data Envelopment Analysis (FDEA), and Chance Constraint Data Envelopment Analysis (CCDEA), Simulation
	S.M. Wagner et al(2009-b)	Supplier default dependencies	Supplier bankruptcy,	supplier development with relationship specific investment and upgrade supplier's performance, creation of a backup supply base of independent suppliers such as located at different parts of worlds etc.
Simulation Model	M.C. Wilson et al(2007)	Investigation of transportation disruption on supply chain	Supply risk, environmental risk	using system dynamics simulation
	Yu,H.(2007)	Effect of disruption risk on supply chain	supply disruption, environmental risk	simulation approach
	Miller, H. E. (2008)	Effect of natural disaster on supply chain	Enviromental risk	simulation approach
	Cigolini, R(2006)	evaluate the collaboration level	Supply risk	simulation approach

		between logistic network within a supply chain		
	Klimov, R. (2008)	investigates effect of various risks	General supply chain risk	simulation approach
	Denis R. Towill(2008)	Management of bull whip effect	bull whip induced risk	Simulation
	Abdelkafi, C.(2009)	Forecasting improvement	Inventory risk, safety stock risk, demand risk	use Bayesian approach, Monte carlo simulation approach
	D.Neiger et al(2009)	Risk identification in a supply chain	Supply side, demand side, internal and environmental risk	Value focused process reengineering methodlogy, simulation
	Thomas et al 2008	impact of 2nd tier supplier failure in supply chain	Supply risk	Simulation

4.4 MAIN FINDINGS

Previously, we have talked about that a supply chain can be attacked or vulnerable to threats through 4 main sides. Supply side, demand side, internal side and environmental side. In fact each and every single threat address by authors or academicians can be placed to any of these four categories. Therefore, to summarize our main findings we have adopted this classification in order to understand which source is addressed a lot by authors and where gap exists. Furthermore, we dig each source into sub classification to understand which specific area requires more attention. In this regard, the following pie chart clearly showing the articles distribution based on above risk classification.

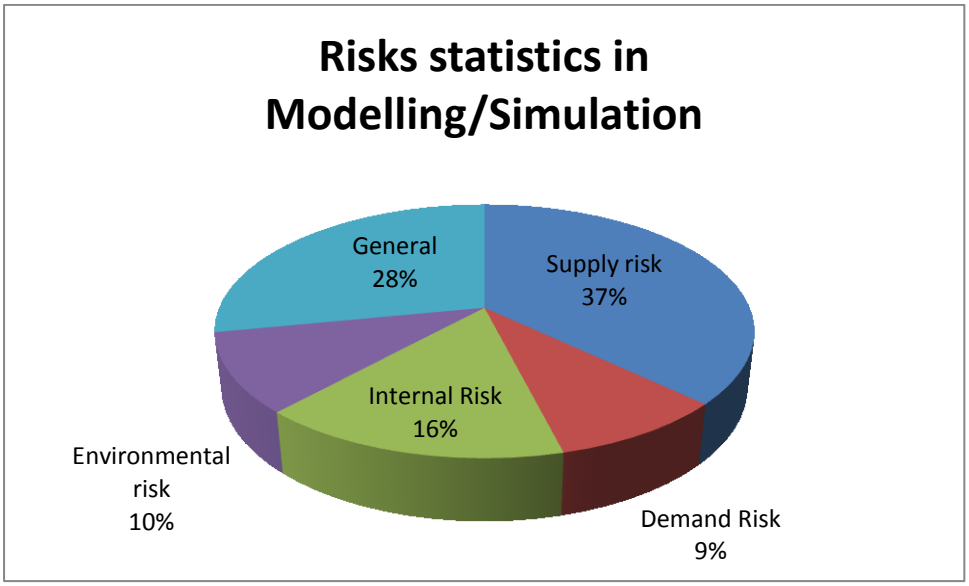


Fig 10: Risk Statistics in Modeling and Simulation

Supply side is addressed most by authors that also show the importance and strategic significance of supply risks. Surprisingly, demand risk is not very well addressed by authors even though of having significance importance in supply chain. We have found 8 articles in total that have talked about uncertainties in demand as in whole. Otherwise, it is addressed with other sources of risks. However, we have found many articles that talked about demand side risks with other types. We have placed all such articles in general categories where author usually presented an overview on all sides of risks. After supply side, internal side is addressed by many authors and finally environmental side also.

According to statistics, risk associated to supply side is addressed a lot by scholars. It is obvious from figure as well. We found 33 articles that have analyzed supply risk specifically in their research without the inclusion of other risks. Beside that it is also addressed in general category with other risk sources.

We found 2 case studies where authors analyzed very important aspect, i.e how should outsourcing decision be made, and what are risk sources involved in it. Such as (Tobias et al 2008) and (Lockamy, A 2010). Furthermore, decision makers need to perform trade-off analysis among expected costs of outsourcing, quality acceptance levels, and on-time delivery distribution. Such as presented by (Wu et al 2008) . Also, (Neureuther, B. D. 2009) concluded that there exists significant trade-offs between the number of suppliers in the supplier base, product diversification, supply chain coordination, and supply chain efficiency that must be examined for a supply chain to remain competitive in a highly risky, vulnerable environment. Most of the time, decision makers try to focus on specific regions for supplier selection to gain accost advantages and cheap labor but not all the time, the suppliers appear to be reliable especially those from third world countries. (Eleftherios et al 2010) propose a single period stochastic inventory decision-making model that can be used for capturing the trade-off between inventory policies and disruption risks for an unreliable dual sourcing supply network for both the capacitated and un capacitated cases. Due to highly turbulent environment and threat of supplier default, firms usually go for backup suppliers also. (Lee, T. Y. S. 2008) , (Jing Hou et al 2009), (Thomas et al 2008),(A.J. Ruiz- et al 2007) and (A.Sarkar et al 2009) analyzed the impact of backup supplier in case of supply risk and proposed models that determine the optimal set of suppliers in the presence of supplier failure risks. Furthermore**,** some authors also tried to examine various outsourcing strategies suitable in different types of risks. Such as presented by (CHEN *et al.* 2010), (Brian Tomlin 2006) and (Tomlin 2009). For example, when supply risks are high, contingent sourcing is more appropriate to implement rather than supplier diversification. On the other hand, when demand risk is high, diversification is more proffered. Readers are referred to these papers for other strategies.

Many researchers considered risks in the supplier selection phase. Beside taken into account different decision criteria like cost, quality, service performance and supplier's profile, different risk factors are considered by authors such as (R R.Levary et al 2008) ,(Jennifer 2008 et al) (Kull et al 2008) (F.T.S. Chan et al 2007). (Canbolat, Y. B. et al 2008) (D.D. Wu et al. 2010) (Chuan et al 2009) (Bindu, R. S. et al 2010) (Azadeh et al 2010) (Ordoobadi, S. M. 2010) (J.K.Deane et al 2009-a) .

When firms and suppliers across a supply chain get together, they tend to have such contracts that not only maximize their profits but allow them to make decisions independently with minimizing risks also.(P. Aggarwal 2007) presented the model that helps manager to make

optimal decisions in quanitity to buy, number of forward contracts to write and when etc. Furthermore, (Sting, F. J. et al 2010) analyzed different contractual practices for firms when they perform global sourcing. Such as how firms should contract with backup suppliers, inducing the latter to install responsive capacity.

Allocating orders to suppliers is of a great importance in managing the supply chain. This process comes after supplier selection and evaluation. Having selected the qualified vendors, the manager will examine the performance of each one and evaluate them. According to the results of periodic evaluations, the manager allocates orders to suppliers. (Haleh, et al 2010) and (Talluri, S. et 2010) proposed models for organizing the process of assigning orders to suppliers. Another important aspect in relationship management is continuous monitoring of quality level of processes or products after having relationship with suppliers. (Kaya and Özer 2009) studied various concepts of quality risks in Outsourcing relationship between Contract Manufacturer and original equipment manufacturer. Authors show impact of different strategies on relationship and results. (Wang, Y et al 2010) explored a model in which a firm can source from multiple suppliers and/or exert effort to improve supplier reliability. Supplier default risk is also considered by many authors. Such as (S.M. Wagner et al 2009-b), (Babich et al 2006) and (Volodymyr Babich 2007). Various strategies that can improve suppliers reliability are proposed by authors. (Cigolini, R 2006) proposed a methodology that evaluate the collaboration level between logistic network within a supply chain.

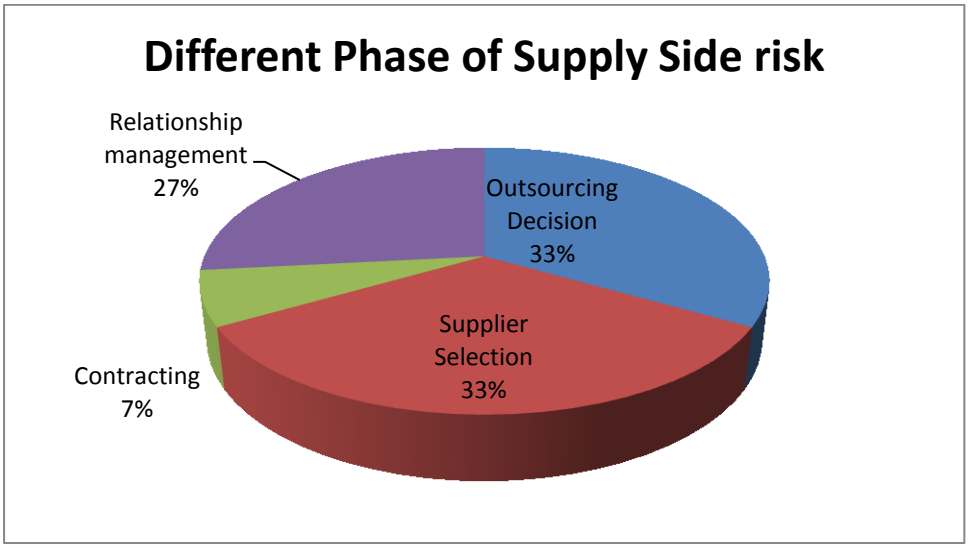


Fig 11: Different Phases of Supply side Risks

There are many drivers that lead to uncertain demand or result with wrong forecasting and prediction. Some of them are addressed by (Chen, F. Y. et al 2010) (Georgiadis et al 2011) (Chandra A. Poojari 2008), (Pan, F et al 2010) and (Xiao, T. et al 2010). These authors have

also proposed various mathematical models for planning decisions under such risks. In term of customer sensitiveness, this topic is addressed by (Faisal et al 2006-a). Furthermore, the impact of uncertain demand on company's inventory and other implications related to that is addressed by (Abdelkafi, C. 2009) .Finally, (Ben-Tal et al 2010) proposes a methodology to generate a robust logistics plan that can mitigate demand uncertainty in humanitarian relief supply chains .

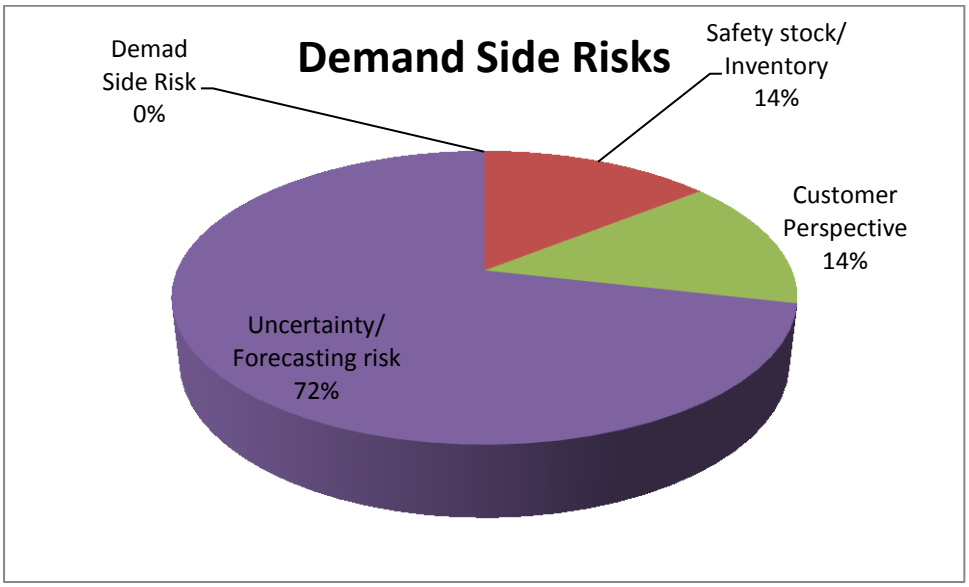


Fig 12: Demand Side Risks

Internal side risks refer to firm's internal risk that becomes vulnerable for whole supply chain. After supply side risks, internal risks are addressed by many authors. An important aspect is the design of supply chain. The design of supply chain can either leads to vulnerable supply chain if not well, or leads to resilience supply chain if risks are considered during design phase. (Miguel Laínez, J. 2009) recommend that supply chain (SC) and product development activities should be coordinated and synchronized to avoid from different supply chain risks. Internal side risks usually arise from firms' internal capability of serving customers and resources. Furthermore, its financial position plays a leading role for surviving in a supply chain. Other than design aspects, various other issues have been discussed. Cash flow related risk for a business entity measured by the standard deviations of cash inflows, outflows, and net flows of each period in a planning horizon by (C.-Y. Tsai et al), treatment of hedging operational risks in distribution systems by (Ta Lin et al 2009), unreliable production capacity by (Wu, Y. et al 2010) , SC organizational performance factors (OPF) and available risk operational practice by (Xia, D. et al 2010), inter-echelon quantity flow by (Kumar et al 2010), risks associated to facility location by (Wang et al 2009), strategic planning for vehicle use under uncertainty in the operating costs by (Sabio et al 2010),

optimal levels of corporate social responsibility (CSR) activities by (J.M. Cruz et al 2008) and risks associated to bullwhip effect by (Denis R. Towill 2008) .

Also, (Tapiero, C. 2008) identified various risks such as risk externalities, external risks, operational risks and strategic risks and proposed a measurement approach to these risks in supply chains. Another organizational risk arises due to security risk in the information system of firms and supply chain. This issue is addressed by (J.K.Deane et al 2009-b) and (faisal et al 2007-a) . Finally, (Xiaoyan et al 2010) studied the methods for reducing the probability of bankruptcy of an organization through supply chain coordination.

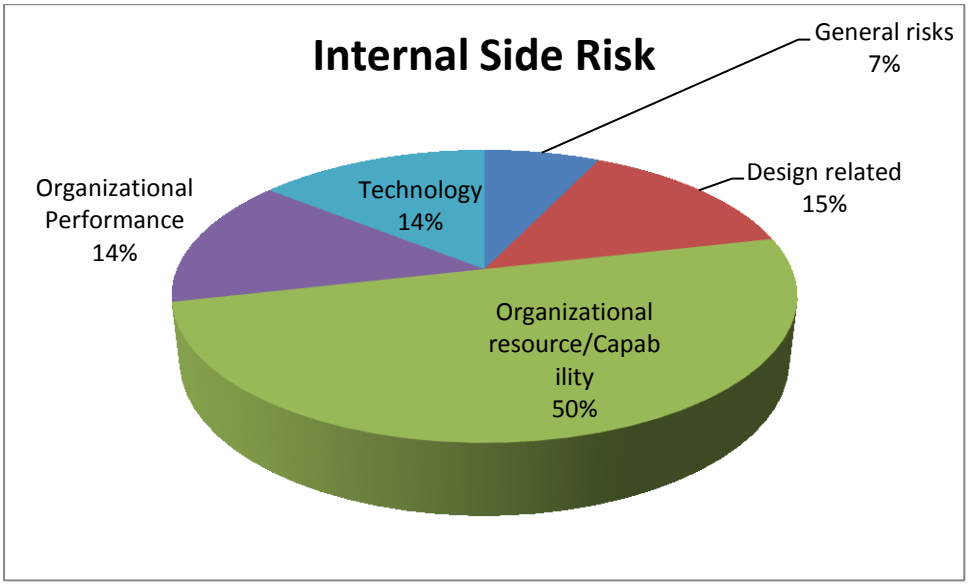


Fig 13: Internal Side Risks

Environmental risk also known as external risks arise due to external factors such as catastrophic events, government regulations etc. (Manuj et al 2008). We have further classified articles into three sub classes, High severity low frequency risks such as disasters, catastrophic events, Low severity high frequency risks such as terrorist attacks, accidents, port delay etc and finally country risks which covers political, legal, currency and other risks as well.

For High severity low frequency risks (Miller, H. E. 2008) studied the effect of natural disaster on supply chain. Furthermore, (Wang, H.-F et al 2010) discussed the risks associated to global warming in their research. Low severity high frequency risks are addressed by (Dillon, R et al 2010) (Faisal, M. N 2007-b) (Moonis, M et al 2010) (Wei&Dong et al 2009) (M.C. Wilson et al 2007) and (Yu,H. 2007). Finally country risks and their impact are analyzed by (R. Desbordes et al 2007) and (Liu, Z. et al 2010).

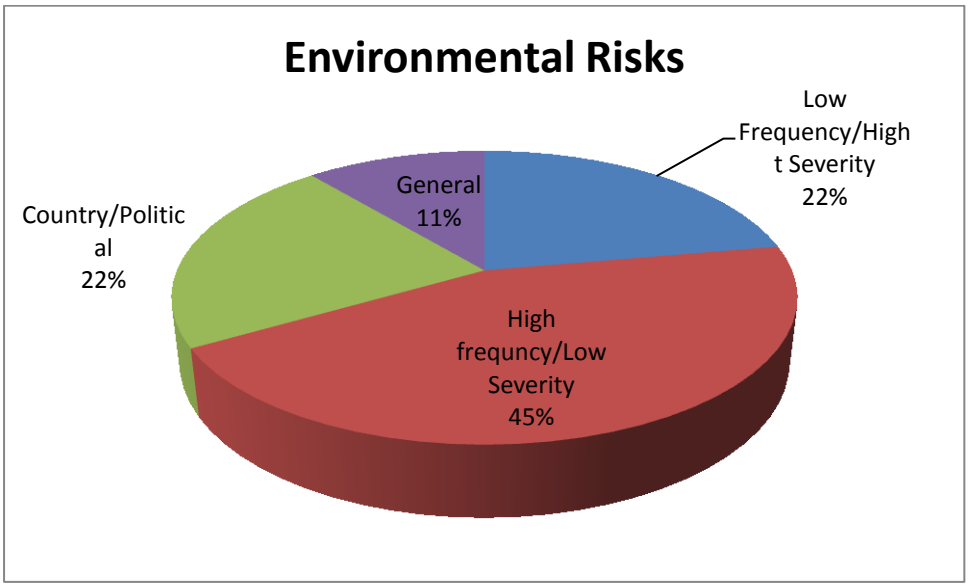


Fig 14: Environmental Risks

4.5 CONCLUSION

In this chapter we have reviewed various quantitative models for managing supply chain risk published prior to 2005. More than 100 articles are considered for this purpose. Starting from simple linear weighting models to complex optimization models we have reviewed all those articles that considered risk in their supply chain related problems. We first tried to enlist all risk factors separately. Furthermore, the treatment strategies used for mitigation are also summarized. Finally, various future research opportunities are provided.

- There are many articles in the databases that contributed toward review of SCRM literature; however, we did not find any article that classified quantitative models covering last 5 years research only. Previous similar work was performed by tang et al 2006.
- The papers are classified according to different modeling types so that researcher or managers can easily identify the articles according to their own needs.
- Furthermore, a brief summary of each article along identified risks are also presented separately for the easiness of readers.
- Similarly, various Approaches and treatment strategies proposed by academicians are also enlisted.
- and finally based on these case studies we are able to determine the gap in research that would be of real interest for many researchers and academicians.

CHAPTER 5

IDENTIFICATION OF RM PROCESSES AND RESEARCH ADVANCEMENT IN SCRM: A REVIEW OF CONCEPTUAL LITERATURE, RISK MANAGEMENT PROCESSES & SURVEY ARTICLES

Overview

In this chapter, we reviewed survey papers, conceptual articles and those articles that have addressed risk management frameworks in their analysis. The articles are further classified into different issues and topics discussed by various authors, such as product design, agility in supply chain and supplier default etc

5.1 INTRODUCTION

Case studies and quantitative models have been reviewed in the previous chapters in a great extent to understand current research practices in SCRM. However, these two aspects themselves cannot provide clear perceptions on SCRM if we ignore other types of articles, such as theoretical articles or in other words conceptual in nature, survey articles etc.

In this chapter, we have reviewed survey papers, conceptual articles and those articles that have addressed risk management frameworks in their analysis. The articles are further classified into different issues and topics discussed by various authors, such as product design, agility in supply chain and supplier default etc

5.2 DIFFERENT RISK MANAGEMENT FRAMEWORKS

(Ritchie et al 2007-b) presented a framework for SCRM and than implemented to manufacturing industry for empirical case example. The different stages of framework are risk context and drivers, risk Management influencers, decision Makers , risk Management, responses, and performance outcomes The different sources of risks are external environmental, industry specific, Supply chain configuration, partner specific and node specific. Risk management influencers stage is specifically analyzed by authors and consists

of reward, risk, timescale and portfolio. In decision maker stage, important factors defined by the author are perceptions, risk profile, attitude and experience. In the next risk management response, the types of strategies are risk taking, avoidance, mitigation and monitoring. Three classifications are profit related, strategic positioning and personal defined by author in performance outcomes. (Wu et al 2006) presented a complete Risk management framework for supplier. Some of the important steps in the framework are i) identification of inbound supply side risks through extensive Literature review and classification of risk factors based on hierarchy,ii) using AHP for risk factors classification and prototype computer implementation system. (Matook et al 2009) proposed a management framework for supplier selection with the help of benchmarking technique. The framework consists of five stages. Supplier risks identification, supplier risk assessment, reporting and decision of supplier's risks, supplier's risks management responses and supplier risks performance outcomes. The authors focus on the stage of supplier risks management responses specifically and discussed strategies related to that. (A.M.Knemeyaer et al 2009) proposed a proactive Risk management framework for the catastrophic events in supply chain. The different stages of the frameworks and techniques used are 1) Identification of key locations and threats (Some useful techniques used for that are disruption analysis network methodology, supply chain mapping exercise, wheel of crisis) 2) Estimation of probabilities and loss for each key location (techniques used for that are expert opinion combined with historical data, expert opinion combined with decision maker's opinion, game theory, catastrophic simulation modeling), Evaluation of alternative countermeasure for each key location and finally Selection of countermeasures(some of the strategies are assume the risk(do nothing), buy insurance, reduce dependencies, invest in key locations to protect more, move key locations etc).

(Manuj et al 2008) presented a comprehensive and integrated step by step risk management model .The following steps are included in their model Identify > Assess and Evaluate > Mitigate > Monitor and Re-assess. Author classified risks as Supply Risks, Operational Risks, Demand Risks, Security Risks, Macro Risks, Policy Risks, Competitive Risks, Resource Risks. Risk assessment tools are divided into three main categories: decision analysis, case study and perception bases. Risk mitigation strategies are mentioned as follows. Avoidance, Postponement, Speculation, Hedging, Control, Transferring/sharing risk, Security

(Pujawan et al 2009) presented a House Of Risk approach proactive in nature used for risks identification, assessment and for mitigating strategies. The idea of HOR is fully taken from QFD approach. Authors divided their framework in to two stages, HOR1 and HOR2. The first stage is assessing different risks and rank based on their aggregate potentials. The second stage used for prioritizing risk management strategies according to selected risks drivers or agents

(Jian Li 2007) constructed a eight step procedure through process mapping tool that help companies not only reducing loss but improve business process to make it loss free. O. I. (Aruoma et al 2006) discussed various implications and significance of Hazard analysis at critical control point (HACCP) a management control system exist in ISO 9000 in food supply chain. An important characteristic this control system is risk assessment in the food though following stages, Hazard Identification, exposure assessment, hazard characterization and risk characterization.

(Adhitya et al 2008) proposed a systematic framework for SCRM that uses Hazarad and operability analysis (HAZOP) method for risk identifications, and identify their possible causes, consequences and proposed safeguards and mitigation actions. Dynamic Simulation model is used for consequences. (Berg et al 2008) also proposed a tentative framework based on quality model to assess the performance of SCRM in any supply chain settings and provide directions for design of such program.

A comprehensive approach was described by (Hans-Peter Wiendahl 2008) for the implementation of operative logistic risk management in the Production planning and control (PPC) within flexible supply chains. The method he developed applies proven statistical fundamentals (e.g. trend analysis) to logistic risk management with the purpose of identifying potential logistic risks, estimating their impact and ranking them according to their importance.

(Park et al 2007) identified various risks involved in global online trading such as environmental risk, strategic risk, technological risk, and operational risk. Furthermore, author proposed a risk management framework for global online trading.

(Adhitya et al 2009) proposed a comprehensive and general approach for Risk management. Author claimed that supply chain network is very similar to that of chemical plant network. Therefore, well established and developed methods currently being used for RM in those plants can easily be implementable to any supply chain network also. Besides presenting risk

identification through structured methodology, author proposed flow and work flow diagram that perform the same job as process flow diagram etc.

(Lackes et al 2010) discusses various characteristic and features that any risk management information system must possess and examined different information risk management softwares within the context of these features.

(Leibesman et al 2008) identified different risk factors any organization may encounter in supply chain . Author argued that these risks can be managed through ISO 90001. Author further presented different stages of effective risk management framework such as definition and compatibility of the organization's objectives, identification of risks to achieving objectives, judgment of which risks are critical and use of risk management tools to mitigate risks.

(Gastaldi et al 2006) analyzed the application of a real option approach for risk management in supply chain. Authors first selected set of uncertainties and risks connected to each source. Author individualized the real options that suit with risks. Further test performed using MATLB to validate the test.

(Lip Tse 2009) introduces a risk mitigation framework for the implementation of Integrated enterprise System in the manufacturing environment. This framework helps ensure that the various risks and Potential Problem Areas (PPAs) are identified at a very early stage and mitigated at the various milestones of the IS implementation project life cycle. A case study of an IS implementation using the risk mitigation framework will also be presented.

(S. Palaniswami 2010) primarily focuses on the security issues in supply chain networks and is organised in three major sections: security risks, security risk assessment and security measures. These three sections discuss existing issues in supply chain security and present several frameworks for improving the overall security in supply chain networks.

(Terry,L 2006) discussed the advantages of supply chain risk management, the process of assessing, monitoring, and mitigating the vulnerabilities inherent in any supply chain.

(Srinivasan, R. S. 2010) describes a methodology for supply chain risk management in manufacturing and services. The methodology leverages the supply-chain operations reference (SCOR) sub-processes to create distributed solutions for supply chain risks. Two key features that cater to the needs of current supply chain risk management are the ability to uncover the impact of the risk over the entire supply chain and rapid reconfiguration of the supply chain.

(Zhang et al 2008) presented a framework consists of six components that identified supply chain risks by cause and effect analysis and hierarchy analysis

(Yanjun, Z. 2009) introduces a trust-based approach to perform effective risk management for controlling and mitigating information risks. Different stages in proposed framework include supply chain member trust evaluation, data classification, and trust-based decision making. The author uses the principle of transitive trust for trust evaluation and uses several decision tools for risk analysis and mitigation.

(Wu, D. D. et al 2010) presented the development and current status of ERM with a demonstration of how risk modeling can be applied in supply chain management. Furthermore, author discussed the advanced ERM technology, i.e. value-at-risk (VaR) and develop DEA VaR model as a new tool to conduct risk management in enterprises.

(Salmela et al 2010) presented a new risk assessment model, the supply chain security and technology management model, by integrating Concept development methods, risk management tools and technology expertise to a process that resulted in effective business solutions for enhancing supply chain security

(Shanthakumar et al 2010) focuses on the security issues in supply chain networks and discussed security risks, security risk assessment and security measures and present several frameworks for improving the overall security in supply chain networks.

(Foerstl et al 2010) explore how leading PSM functions identify, assess, and treat supplier sustainability risks and elaborate on the integration of sustainability risk management in supplier management processes. Based on the findings from a multiple case study in the chemical industry and by drawing on the dynamic capabilities view (DCV), Author propose that mature and sustainable supplier management capabilities are a source of competitive advantage in terms of lower exposure to reputational risks and enhanced operational performance.

(Giannakis et al 2010) develops a framework for the design of a multi-agent based decision support system for the management disruptions and mitigation of risks in manufacturing supply chains.

(Agrawal et al 2010) developed The Organization Risk Evaluation (ORE) framework based on the design science paradigm as a multi criteria, relative risk, condition consequence, management decision framework enabling executive decision makers to calculate and compare risk evolution at fixed points of the change cycle and make structured and balanced risk mitigation decisions.

(Bob Ritchie et al 2010) developed a conceptual framework for performance and risk management within the supply chain from the literature and empirical evidence.
(Elisa, et al 2007) explored mechanisms that can limit materials availability, effects of such limits on the firm, preliminary metrics to diagnose these risks, and strategies to reduce a firm's risk exposure.

5.3 CONCEPTUAL ARTICLES

(S.K.Cheng et al 2008) has presented a conceptual framework using the Principal Agent concept for analyzing the complexities of supply network risk with particular emphasis on the role of network relationships The author concluded that dynamics of risk in network systems depend not only on the typology of networks, but also on the functional role of each collaborator inherent in the network through agreements on supply and incentives, and supply performance. The proposed framework provides a structured approach for identifying and assessing risk dynamics and their differential impacts on different levels of supply networks.
(Bhat, S. K. S. a. A. 2009) analyzed how supply chain management solves various strategic issues with the help of literature review and experts opinion. Authors defined the risk from the decision theory perspective, Royal society and social scientists perspectives. Author further argued that there are two types of dependencies among the supply chain partners, time dependency and functional dependency. These are also the basic reasons for vulnerability also, so risk management cannot be performed at firm level but it has to be performed on supply chain level by considering each and every linkage.
(G.T.Stewart et al 2009) developed a community resilience framework based on resilience and Public Private Partnership.The interdependencies amongst public and private sector organizations, critical infrastructures/key resources (CI/KR), supply chains, and local communities were used to highlight opportunities for improving resilience in the aftermath of disasters. The author concluded that interdependent systems like social and economic networks will ultimately influence the ability of communities to adapt and respond to the consequences of disasters. In addressing the resilience of these systems, all levels of government must recognize and embrace the public-private interfaces that can improve their ability to manage the response and recovery phases of disaster management.
(Kovacs, G 2009) examines the capabilities of supply networks to manage disruptions, based on their resource configuration in a dormant preparation state. The article concludes by presenting how different types of supply networks can manage large-scale disruptions.

(Enrico Briano 2010) identified most common threats affecting supply chain integrity and success factors needed to build a supply chain resilience.

(McKinnon, A. 2006) analyzed Inventory levels, lead times, dependence on road transport and opportunities for substitution in critical sectors during catastrophic failures. Author suggests that there would be huge economic losses and a rapid deterioration in living conditions if there were a week-long disruption in all truck traffic

(Pettit, T 2010) presented a conceptual framework which suggests that supply chain resilience can be assessed in terms of two dimensions: vulnerabilities and capabilities. The Zone of Resilience is defined as the desired balance between vulnerabilities and capabilities, where it is proposed that firms will be the most profitable in the long term.

(Wu,X. 2006) analyzed the sources of supply chain enterprise risk from different aspects including material flow, information flow, cash flow and partner relationship . Measures for risk reduction have also been summarized from the aspects of risk sharing, information sharing, change of inventory control mode, and supply chain flexibility.

(Cannon, A. R 2008) established theory bases from other disciplines that may be used to illustrate the benefits, complexities and risks accompanying the adoption of radio-frequency identification (RFID) technology. The author explored three theory streams with respect to RFID adoption at two levels: the level of the tagged unit; and the level of the adopting firm. Each theory stream is evaluated specifically with respect to RFID, and research questions are proposed.

Postponement has recently been mentioned as a useful tool for managing supply risk and disruptions. (Yang, B. 2010) has attempted to explore the role of postponement in supply chain risk management from a complexity perspective.

(R. Glenn Richey Jr 2009) integrated four prominent existing theoretical perspectives the RBV of the firm, communication theory, competing values theory, and relationship management theory to provide framework for grounding future research.

(V.S.Rodrigues et al 2008) investigated supply chain uncertainty from a transport perspective. Author Identified five main categories of uncertainty supplier side, customer side and the carrier side, the control systems used in the supply chain and external factors. The interfaces between the uncertainty categories involving all three parties of the logistics triad are identified.(Tapiero, C. 2008) identified various risks such as risk externalities, external risks, operational risks and strategic risks and proposed a measurement approach to these risks in supply chains. Integration of information flows through advanced IT systems has

increased collaboration across supply chains. However, it also make supply chain more vulnerable. (Smith, G. E. 2007) identified, categorized, and validates information technology threats as sources of risk in the supply chain. Author further established a conceptual framework for further study into supply chain information security risk.

(Enyinda, C 2008) examines the prevalence of global value chain drug counterfeit and Pharmaceutical Value Chain vulnerabilities.

(P. W. Stonebraker 2009) has outlined a diagnostic process that can be used in brainstorming and decision-making processes by senior management of for-profit, not-for-profit, governmental, and non-governmental organizations to systematically identify and assess the level of supply chain risk and to plan investments toward the continued profitability of the business.

(Faisal, M. N 2006-b) . Identified and ranked the enablers of risk mitigation in supply chains. Furthermore, author found the interaction among identified enablers using Interpretive Structural Modeling and discussed managerial implications

(Skipper, J 2009-a) examined relationship between various attributes of contingency planning and flexibility. Authors found that largest contributions to flexibility are provided by top management support, resource alignment, information technology uses and external collaboration. (R.A. Dowty et al 2009) argued that Organization's cultural behavior plays an important role in managing effective supply chain management. Authors used 4 cultural biases high grid high group, low grid low group, high grid low group, low group high grid. Authors analyzed cultural bias exhibited from organizations during supply chain disruptions. Authors analyzed the implications of these cultural biases on organizations during supply chain disruption and how these affect inter-organizational coordination. (Ponomarov et al 2009) provides an insight into the literature review of resilience both in ecosystem and psychology. Authors found that not much work has been done on this subject and term supply chain resilience often misunderstood. They also concluded that supply chain resilience need to be researched from logistic perspective. The authors proposed a conceptual framework of relationship between supply chain resilience and logistic capabilities.

(Braunscheidel et al 2009) proposed a conceptual framework for Agility of supply chain and analyzed its importance for supply chain disruptions. Authors analyzed the correlation of 2 main cultural antecedents, 3 main practices lead to agility and check their impact on firms agility. The two main antecedents are learning orientations and market orientation. Three organizational practices are internal integration, external integration with upstream and

downstream partners and external flexibility. Three practices got positive relationship with firm's agility. Market orientation has positive impact on all three practices. Learning orientations got impact on internal integration only. Firms with high external integration are found to have strong internal integration also. Internal and external integrations are not related with level of external flexibility.

(Kumar et al 2011) studied and analyzed the management of recalls in a consumer products supply chain, as well as the reasons, costs, and measures to prevent recalls. Author used Six Sigma DMAIC methodology to understand the root causes and management of recalls and also analyze the costs in a consumer products supply chain.

(Stanley et al 2010) addressed how companies mitigate existing forces to achieve the collaboration enabled supply chain (SC). Based on Seven key theories, author provided insight into the theoretical framework for the creation of the collaboration-enabled SC: contingency theory, the resource-based view of the firm, the relational view of the firm, force field theory, constituency-based theory, social dilemma theory, and resource-advantage theory.

(Villax et al 2010) analyzed the issue of Counterfeit medicines and put it as serious threat that takes patient risk to unacceptable levels. Furthermore, author claim that countries do not yet as threat to pharmaceutical supply chain.

(Yang, B et al 2010) has attempted to explore the role of postponement in supply chain risk management from a complexity perspective. Author also investigates the complexity implications of some commonly recommended measures to mitigate supply chain disruptions. In certain circumstances, the introduction of those measures may add to the complexity of a system and thus become inherently infeasible.

(Erik et al 2011) describe and analyze the concept of natural hedging in supply chains. Author has shown that a globally active focal firm can hedge currency and commodity price risks (financial components), as well as operational supply risks (physical components), by centralizing the commodity supply with its SME-suppliers.

(Pyke, D. et al 2010) proposed a framework that can help companies to develop a process for preparing for, responding to, and recovering from product safety issues. We also highlight various challenges that companies must overcome and suggest some new opportunities for improving product safety.

(Cigolini et al 2010) proposes a model to analyze and to assess the operational risk at the drilling, primary transport and refining stage of the oil supply chain.

(Ellison et al 2010) analyzed various risks associated to software and hardware supply chain risks . Author further identifies several current practices that can be incorporated in an acquisition to reduce those risks.

(Eric et al 2010) discussed various opportunities that businesses have to grow their operations in a more scalable way with a higher level of investment in variable-cost resources and assets. Author has provided a four-step approach that businesses can follow to identify and capture supply chain opportunities where a scalable and flexible model might be most sensible to consider.

(Farooq et al 2010) present result obtained from a developed technology selection framework and provide a detailed insight into the risk calculations and their implications in manufacturing technology selection process conducted at aerospace company.

(Fu, J et al 2010) extends prior work in the area of SCRM by adding a relational-cultural dimension. With a view to mitigation of SCRRs, the authors develop a conceptual process model, which describes a relationship-building process incorporating cultural adaptation for the creation of a mutually beneficial partnership, which features a hybrid cultural interface.

(Hult et al 2010) extended real options theory to the supply chain context by examining how different types of options are approached relative to supply chain project investments. Specifically, author theorized how the options will be related to perceived value under conditions of high supply chain risk uncertainty.

(Risto Talas et al 2010) introduces a conceptual model that uses the Markowitz (1952) theory of portfolio selection to describe the process that ports and port terminals can follow to ensure that efficient security investment decisions are made to reduce the exposure to terrorist and other unlawful activities.

(Choi, et al 2006) propose to take a significant step toward developing a theory of supply base management. In reviewing the literature on buyer–supplier relationships and supply base management, they concluded that further development of a theory of supply base management is currently being impeded by the lack of a well-accepted set of terms and definitions. Author developed definitions to describe and differentiate the supply base from other related concepts.

(Dani, S. et al 2010) seeks to identify and understand the varied approaches, the contributing factors and the relevant legislation towards risk control as a reactionary measure in the food

sector with the help of secondary data. Furthermore, author proposes a conceptual model for risk mitigation from a reactionary standpoint which is retrospectively validated using selected case studies.

(Hamid Mohtadi 2009) compiled database of international terrorists and analyzed that how food supply chain could be attacked. The different likely agents diagnosed by authors were chemical, biological, or radionuclear. With the help of statistical test, author calculated likelihood of such event.

(Altay et al 2010) presented exploratory study by taking an indirect approach and investigates disaster impact on firms in various industry sectors using secondary data. Author concluded that disasters impact all sectors within a supply chain. Furthermore, damage by windstorms and floods seem to be dramatically different from that of an earthquake, providing evidence against the all-hazards approach.

5.4 LITERATURE REVIEW/SURVEY PAPERS

There are 10 excellent reviews of supply chain risk analysis published by various authors. These reviews offer different perspectives in the following sense. Some Authors studied and investigated various risks perceptions from literature and their relationships with risk management strategies. Such as (Peck et al 2006) performed detailed analysis by studying different interpretation of risks in supply chain and their relationship with risk management. The author concluded that perceptions about risks and their respective strategies exist in literature vary greatly in the supply chain and other related functions. The author further proposed that issue of SCRM should not be matter of concern for Supply chain personnel only but it has to be seen on broader side. i.e. other managerial disciplines should also focus on this issue . (Omera khan et al 2007) also developed a research agenda for risk and supply chain management. Their research is focused on to answering various dimensions of risk and their importance in supply chain. Furthermore, the author discovered various strategies mentioned in SCRM literature. (David et al 2010) reviewed SCRM literature by identifying and classifying different types of risks, cases, and models with emphasizing on China. (Ou Tang et al 2010) also review and identified various potential risk associated with different flows, namely material, cash and information flows along their treatment strategies.

Besides the work of (peck et al 2006) and (Omera khan et al 2007), (Tang et al 2006) reviewed various quantitative models for managing supply chain risks. He also related various supply chain risk management (SCRM) strategies examined in the research literature

with actual practices. He classified his research to 4 main categories supply management, demand management, product management and process management. Many authors analyzed literature in SCRM by classifying articles in to unique frameworks. (Mailani et al 2009) performed exhaustive literature review on SCRM by focusing not only SCM journals but OR/management journals also. The authors develop a unique classification framework for supply chain crisis management literature based on five factors: source, stage, scale, respondent, and the scientific research method employed to address the crisis. Furthermore, (Rao et al 2009) also reviewed the growing literature by examining supply chain risk management (SCRM) and developed a typology of risks in the supply chain. Their typology consists of risk sources, consisting of environmental factors, industry factors, organizational factors, problem-specific factors, and decision-maker related factors. (Iwan 2009) surveyed supply chain risk management (SCRM) literature by reviewing papers published in relevant journals from 2000 to 2007 and classified into five categories: conceptual, descriptive, empirical, exploratory cross-sectional, and exploratory longitudinal. They also looked at the papers in terms of the types of risks, the unit of analysis, the industry sectors, and the risk management process or strategies addressed.

They are very few papers that examined the articles on selective area of SCRM. Such as (Qin and Tang et al 2010) reviewed various quantitative models in SCRM with logistic aspect by concluding the fact that major disruptions usually impacted logistic systems. The author classified there review as design problem type, disruptions modeling form, decision-maker risk attitude and underlying logistics system model, the range of quantitative models for designing reliable logistics system under disruptions and their potential modification etc. Next, in the context of supply chain security, (Zachary et al 2009) reviewed the Literature and distinguished supply chin security from supply chain risk however the author also linked both of them. SC security is defined as those measures or procedure or policies implemented to prevent supply chain from theft, damage and specifically terrorism activities. In a general Supply chain risk management context, Sc security is placed in risks mitigating strategies stage. Author further claimed that though much work has been found on SCRM, but SC security was ignored by academician.SC security approaches available in literature are categorized as An Intra-organizational perspective: those security measures usually performed inside the organizations. An Inter-organizational Perspective: security activities performed at supply chain level Combination of Inter and intra organizational approaches: mix approaches from both. Ignore: if no security measure were implemented by firms due to

some reasons. Those areas affected by security measures are Inventory management and customer service, visibility, efficiency, resilience and customer relationship.

Table 12: Topic wise Litertaure classification

Supplier Selection criteria with Risks considerations	**Micheli et al(2008), R R.Levary et al(2008), Kull et al(2008), F.T.S. Chan et al(2007), Lee, T. Y. S. (2008), Eleftherios et al(2010), A.Sarkar et al(2009), D.D. Wu et al.(2010), Wu et al (2008), A.J. Ruiz- et al(2007), Chuan et al(2009), . Li &Barnes et al(2008), L. Tate(2009) , Bindu, R. S. et al 2010**
Global Sourcing Issues	Manoj, U. V.(2009), Sameer Kumar(2007) , Jiang et al (2009), Martin et al 2011, Reuter et al 2010, Azadeh et al 2010, Colicchia et al 2010, Erik et al 2011, Choi, et al 2006
Effect of Supplier default	S.M. Wagner et al(2009-b), Babich et al (2006), Volodymyr Babich(2007)
Assessment of Outsourcing Strategies/ risk treatment strategies	CHEN *et al.*(2010) Kaya and Özer(2009) Jing Hou et al (2009) J. Li et al(2010) *H. Yu et al*(2009) G. Lai etal(2009) Sunil Chopra(2007) Brian Tomlin(2006) Thomas et al 2008 S.K.Cheng et al(2008)
Supply Risk management process	Ellegaard et al(2008) Wu et al (2006) Matook et al(2009) Dillon, R et al 2010 Foerstl et al 2010
Supply Chain contracts	Chen et al Yang, Z. B et al. (2009) Haksöz, A(2009) Bakshi, N(2009) T. Xiao et al (2009) Zhou, K. et al 2010 Chen, F. Y. et al2010 Yu,H.(2007) Xiao, T. et al 2010 Sting, F. J. et al 2010
Agile Supply Chain	A.S. Oyegoke et al(2008) Samir Dani(2008) R. Masson et al(2007) Braunscheidel et al (2009)
Software in SCRM	nagali et al (2008) Ellison et al 2010 Lackes et al (2010)
Types of Supply Chain/SC design	I.S.Papadakis et al(2006) Craighead(2007) Neureuther, B. D.(2009) Pan, F et al 2010
Logistics /transportation	Ojha&gokhale et al(2009) D. Ekwall et al(2009), V.S.Rodrigues et al(2010) Tsai, M. C et al(2008) M.C. Wilson et al(2007) -Peter Wiendahl(2008) V.S.Rodrigues et al(2008) Ponomarov et al(2009) Ben-Tal et al 2010
Six Sigma /Qualitative tools	Kumar, S(2008) Kumar et al 2011
Product Design In Supply Chain	omera khan et al(2008-a) Omera khan et al(2009) Miguel Laínez, J.(2009) Lee, R. P. et al 2010 Pyke, D. et al 2010
Effect on Employee/SCRM	C. Reade et al (2009) Jiang et al (2009)
RFID: Technology in SCRM	Lim, S. H.et al(2009) Cannon, A. R(2008)
Global Vs Domestic Supply Chain	Illa manuj et al(2008-b) Bhattacharyya et al 2010
Supply Chain Security	Autry&Bobbit et al(2008) Urciuoli, L. (2010) S. Palaniswami(2010) Salmela et al 2010 Shanthakumar et al 2010
Supply Chain Contingency Planning	Skipper, J(2009-b)

Firms's policy Vs SCRM	D. Weiss, et al(2009)
Non- Profit Organization – Humanitarian Supply Chain	Ron McLachlin(2009)
Information risk/E-Commerce & SCRM/IT risks	M. Eric Johnson(2008) Ratnasingam, P. (2006) S. Pavlou(2008) A. Brun et al(2006) J.K.Deane et al(2009-b) Bandyopadhyay(2010) Park et al(2007) Lackes et al (2010) Yanjun, Z.(2009) Deane et al 2010
Ecological Supply Chain	Ji, G. J. (2009)
Trust in Supply Chain	Laeequddin et al(2009) Yanjun, Z.(2009)
Coordination & Collaboration Mechanism in SCRM	Yu,H.(2007) Xiao, T. et al 2010 Xiaoyan et al 2010 Lee, J. et al 2010 Cigolini, R(2006) Ramesh et al 2010 Stanley et al 2010
Organizational Culture	R.A. Dowty et al(2009) Fu, J et al 2010
Decision making Process [Resource Allocation under uncertainties + planning]	Chandra A. Poojari(2008) Wang et al(2009) Chun-Ta Lin et al(2009) Kumar et al 2010 Sabio et al 2010 Xia, D. et al 2010 Talluri, S. et 2010 Haleh, et al 2010 Pishavee et al 2010 Georgiadis et al 2011 Fengqi You(2009) Deniz, E.(2008) P. Aggarwal(2007) Emmett J. Lodree(2008) A.Azaron et al.(2008) Peidro, D. et al 2010 Liu, Z. et al 2010 Ordoobadi, S. M. (2010
Consumer Behavior	faisal et al(2006-a)
Quality Control	C.S. Tapiero et al(2007) Tse et al 2011
Catastrophic Events	Miller, H. E. (2008) A.M.Knemeyaer et al(2009) McKinnon, A. (2006) W. Stonebraker(2009) **G.T.Stewart et al(2009)** R. Glenn Richey Jr(2009) Altay et al 2010
Performance and SCRM	Berg et al (2008) Blome et al 2011 Bob Ritchie et al 2010 Wu, Y. et al 2010

5.5 SCRM FRAMEWORK BASED ON ISO 31000 RM GUIDELINES

International standards Organization has established a number of principles that need to be satisfied to make risk management effective. Furthermore, ISO recommends for organizations to develop, implement and continuously improve a framework for risk management under these guidelines and principles into their governance, strategy and planning, management, reporting processes, policies, value and culture. Important elements of ISO 31000 risk management frameworks are communication and consultation, establishing the context, risk identification, risk evaluation, risk treatment and monitoring and review. These steps are also clear from fig 15.

In order to understand the previous research performed by academicians on aforementioned RM steps either separately or altogether, a sea of articles and different proposed frameworks related to SCRM have been reviewed and analyzed. These frameworks and review articles helped us to determine a structure of a framework based on frequency of citations and previously proposed theoretical frameworks. Based on these, we were able to determine that almost all articles have focused on three main phases of risk management process, risk identification, evaluation and treatment. None of the articles has discussed ISO 31000 RM

Fig 15: ISO 31000 RM steps

framework thoroughly. In this chapter, we have limited the scope of ISO framework and focus on these three main aspects of risk management framework. However, the remaining phases of ISO framework are also discussed in detail in term of their applicability to supply chain.

Our objective is to understand the applicability of ISO 31000 RM process to a typical supply chain where some time 100 of members would appear as part of that supply chain in terms of manufacturers, 1st tier suppliers, 2nd tier suppliers, retailers, distributers, 3PL and customers. For each phase or step, after defining it according to ISO principles, we provide basic steps of implementation of that phase to a supply chain along with difficulties and issues that can be raised during the process, tools, expected outcomes and checklists for successful implementation. This phenomenon can also be viewed from fig16.

Communication and consultation, establishing the context and risk identification come at the very beginning stage of this framework. Risks are events that, when triggered cause problems. Hence this step can be initiated from source of the problem or within the problem. We have reviewed those techniques mentioned in articles for identification of risks. Once risks identified, they must be then assessed as to their potential severity of loss and the probability of occurrence. We have reviewed those techniques which help to assess the risks and finally once the process of risk assessment is finished, appropriate risk management strategies can be adopted. These strategies can be classified into two main categories, Proactive Strategies and Reactive Strategies. The Literature is full of different strategies. Some of them were classified as general. Some of them were very specific.

In the coming sections, we present each of phases in the context of results obtained from literature review performed previously.

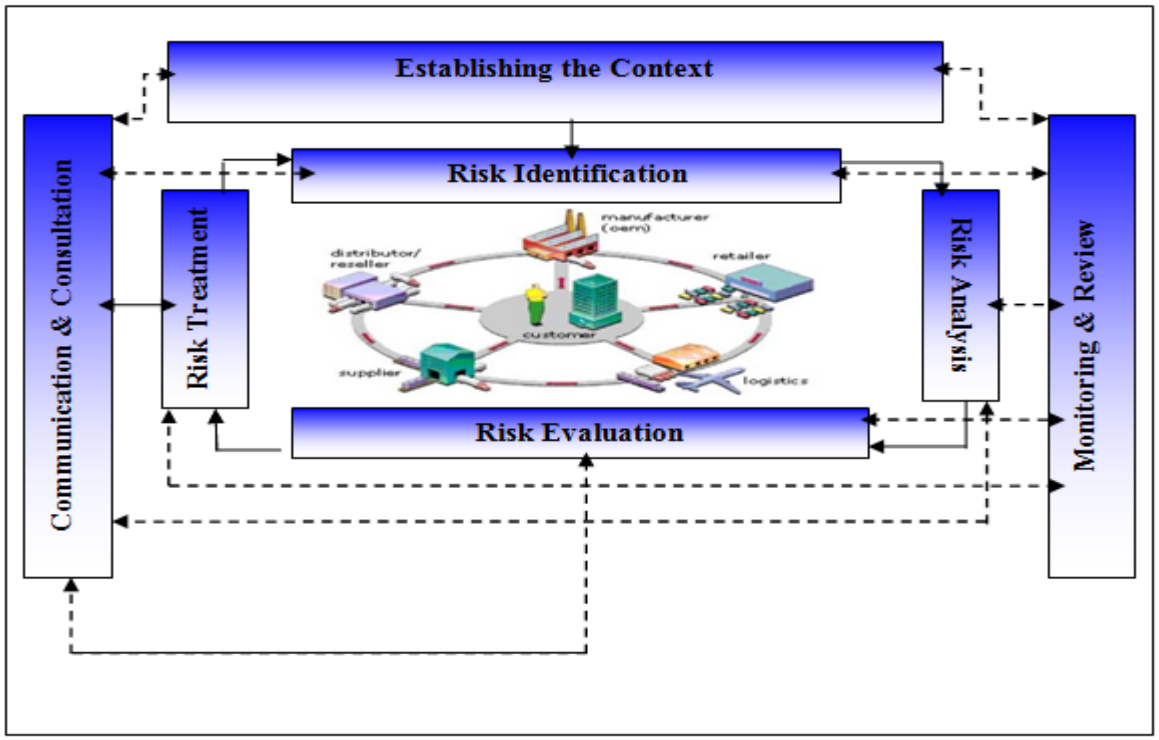


Fig 16: Integrated ISO 31000 SCRM process

5.5.1 COMMUNICATION AND CONSULTATION

In this step, all communication and consultation activities with internal and external stakeholders are handled. Following are the sub processes in this step with brief explanation with regard to supply chain management.

5.5.1.1 Identification of Stake Holders

In this step, the relevant stakeholders for supply chain are identified. Stakeholders are people and organization. Stakeholders are defined as "any group or individual who can affect or is affected by the achievement of the organization's objectives.(Mitchell et al 1997). For a supply chain, sometime members are in dozens or even more than that. So it is almost impossible to get them all work together on risk management. The best approach to adopt in this case is to at least have close partners or suppliers or those having significant importance in the loop of risk management. Over the time, this could be increased to other suppliers and members. Stakeholders may include

- Supply Chain/Logistic manager from each member

- Risk Manager
- Customer(s) served by supply chain
- Relevant Regulators

5.5.1.2 Identification of Stakeholder needs

In this step, the goals and needs of the stakeholders in a supply chain regarding the relationship in general and risk management in particular have to be defined. It is of special importance to identify possible conflicting goals of the stakeholders and how these goal conflicts are managed or resolved. Even in a single organization while doing risk management, due to conflicting goals and responsibilities of members from different departments make the process difficult. But at least they are all working towards the same strategic goals and missions. With a supply chain, now there would be large group of supply chain members with different range of objectives, constraints and agendas which might make it difficult to translate their broad views into practical operations. Some members might have the objective of maximizing profit and cost reduction while others have customer satisfaction and improved service levels. So overall, two important steps need to be taken

1) Overall objective and expected outcomes of the supply chain
2) Clarification of the contribution of stakeholders to the relationship and risk management process, including their roles and responsibilities.
3) Acknowledge the importance of risk management, get senior management understanding and approval, and set up the necessary organizational infrastructure.
4) Analyse the organization's risk strategy, attitude towards risk and policies and review the consequences for SCRM.
5) Define a supply chain risk strategy to give the context for all other decisions, including attitudes towards risk, aims, methods and procedures.
6) Do audits to describe the details of the supply chain, and define the scope of supply chain risk management (particularly whether this refers to the whole supply chain or some limited part of it).
7) a review of the resources, systems, tools and facilities available for SCRM;

5.5.1.3 Establishing Communication and Consultation Plan

Following this, general analysis and overall understanding of the overall goals of the stakeholders, their specific communication needs regarding the risk management activities have to be established and documented in a communication and consultation plan. This plan also includes a definition of the issues on which the stakeholders have to be consulted. The plan should at least include

- Definition of the type of information that is needed from each process step
- The frequency of information exchange
- The medium of information exchange

5.5.1.4 Execution of Communication and Consultation Plan

Finally, the communication and consultation plan has to be executed. The person in charge for overseeing the fulfillment of the plan has to be named. The main responsibilities during the execution of the plan, and therefore during the execution of the remaining risk management process are

- Involve stakeholders in execution and improvement of risk management process.
- Evaluate effectiveness of communication and consultation activities**.**

A graphical representation of all main steps, expected outcomes and some qualitative tools helpful for communication and consultation are briefly elaborated in the next page.

5.5.2 ESTABLISHING THE CONTEXT

The step of establishing the context defines the objectives, scope and criteria for the risk management process. It consists of four sub processes.

5.5.2.1 Definition of Risk Management Organization and Risk criteria

In the definition of risk management organization and the risk criteria, all risk management process related decisions are made. This include

Goals of the SCRM Process

- designing a supply chain risk strategy that fits in with higher organizational risk strategies and sets the context for SCRM;
- meeting any legal, regulatory, contractual or societal requirements for risks;
- embedding risk management within the function of supply chain management;

- ensuring appropriate resources, systems, facilities and infrastructure for SCRM;
- identifying best practices for supply chain risk management, with relevant procedures, technology, information and planning;
- using these practices to identify, analyze and plan responses to risks that are relevant to SCM;
- implementing the planned responses to risks when necessary, and controlling the subsequent actions;
- monitoring performance and continually developing and improving methods;
- Cooperating with other parts of the organization and members of the supply chain to give a coherent attitude towards risk.

5.5.2.2 Roles and Responsibilities of people involved in RM

- a review of the organization's attitude towards risk, extracted from its broad strategies and consequent objectives for SCRM;
- statements of who is responsible for the strategic management of risk within the supply chain, the work of a risk committee, its membership, and other details of the management structure;
- identifying risk owners that have the accountability and authority to manage risks; such as if such a risk occurs which member has to respond it, what course of action need to be taken by which members etc
- Identifying who is accountable for the development, implementation and maintenance of the framework for managing risk;
- Identifying other responsibilities of people at all levels in the supply chain for the risk management process**;**
- establishing performance measurement and external *and or* internal reporting and escalation processes; and ensuring appropriate levels of recognition
- Selection of appropriate and best person for specific tasks and assignments from all members of supply chain

5.5.2.3 Integration of RM process

5.5.2.4 Methods to be used in different risk Management Process

- procedures, methods and tools for assembling a list of risks and their causes, likelihoods and consequences;

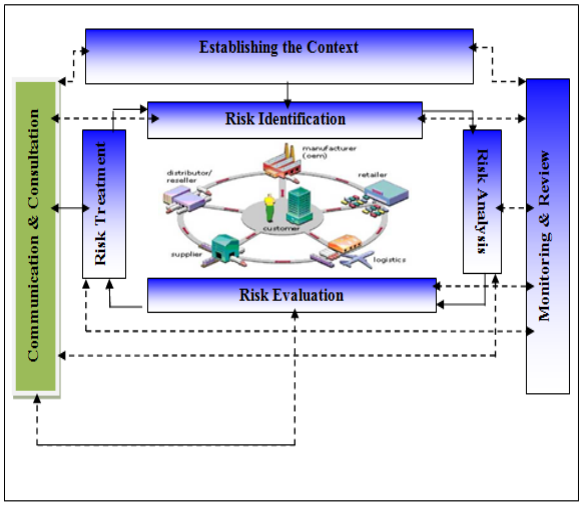
- procedures, methods and tools for analyzing the impact of risks and their significance;
- procedures, methods and tools for designing alternative responses to the risks and selecting the most appropriate;
- policies for allocating and sharing risk among stakeholders; methods for monitoring risk, maintaining the risk management process,

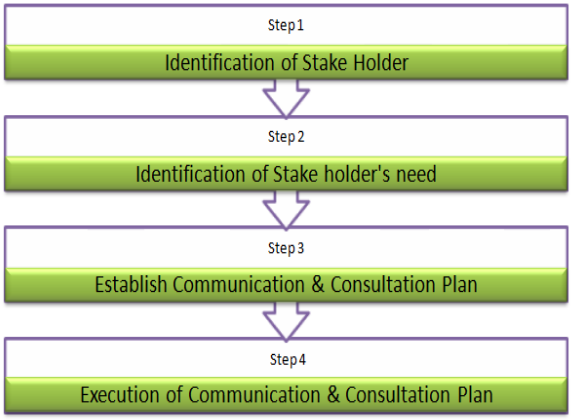
5.5.2.5 Definition of likelihood and impact scales

When more than one organization is involved, getting consensus on common likelihood and impact scales is difficult. There can be basic disagreement about the likelihood of an event and particularly their consequences. Usually such difference appears due to having different perceptions about risks. So at this step, after having negotiation with all stakeholders, consensus must be achieved on definition of likelihood and impact scales.

5.5.2.6 In scope and out scope activities involved in RM

Similarly, getting consensus on in scope and out scope activities is also difficult due to the fact that some member of the supply chain give importance to particular type of risk while other give to some other type. In this way, making decision about in scope activities and out scope activities need to be planned in such a way that it has to be cleared and linked with over all supply chain stakeholder's objectives.





1. Identification of Stake Holders:

- Supply Chain manager [from each individual member]
- Risk Manager [from each member]
- Customer served by supply chain
- Representative from all companies managing the relationships
- Relevant Regulators

2. Identification of Stakeholder needs

Objective of supply chain: planning, implementing and controlling the efficient, effective forward and reverse flows and storage of goods , services and related information between the point of origin to the point of consumptions.

Expected Outcomes

- Increased efficiency
- Improved expertise/market knowledge and access to data
- cost savings or revenue
- Customer service improvement (particularly related to delivery time)
- The re-engineering of the logistics processes
- Access to new technologies and methods to perform the function[from customer's perspective]
- More effective utilization of firm's human and physical resources
- Risk reduction[risk manager's perspectives]

3. Establishing Communication and Consultation Plan

- Definition of the type of information that is needed from each process step
- The frequency of information exchange
- The medium of information exchange

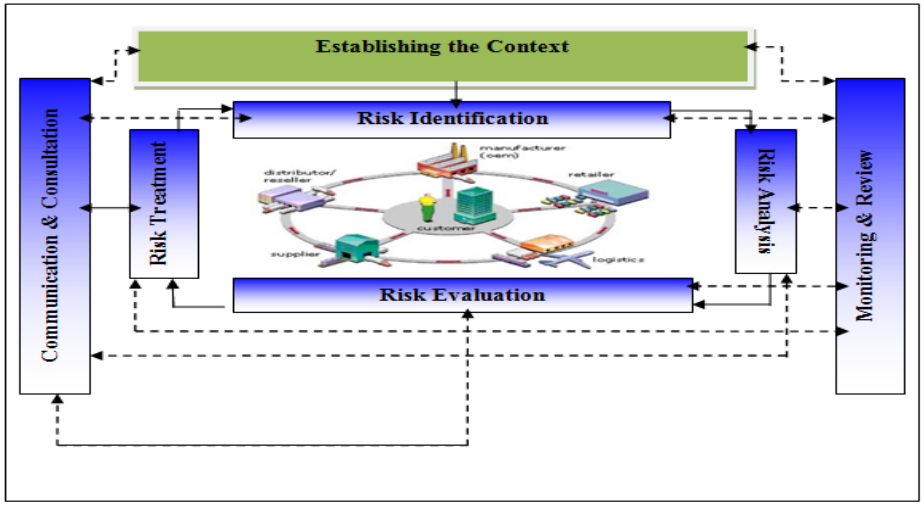
4. **Execution of Communication and Consultation Plan**

Tools:

Risk Management Project Charter

- SIPOC
- Customer Orientation
- Customer or stakeholder Voice chart
- CTQ matrix
- CTB Matrix

- All RM team member's roles are identified
- All project participant possess the necessary information and resources for the project
- The capacity of team members for their project is ensured
- The team members know their roles and aware of their functions and responsibilities within the project
- RM process goals are formulated SMART
- Focus and scope, net benefit, milestones and project schedule are defined and agreed on
- The process is depicted and limited to ISO31000 RM Steps
- The key outputs and Stakeholder of the process are identified
- The Voice of the customer and Businesses are collected and classified
- The Voice of the customer and Businesses are translated into specific and measurable



1. **Definition of Risk Management Organization and Risk criteria**

Goals of the RM Process:

" the identification, assessment, and prioritization of **risks** in 3PL process(while planning, implementing and controlling the efficient, effective forward and reverse flows and storage of goods , services and related information between the point of origin to the point of consumptions) to minimize, monitor, and control the probability and/or impact of unfortunate event"

2. **Roles and Responsibilities of people involved in RM**

In this step, duties and tasks are assigned to each representative of different business partners in supply chain

3. Integration of RM process

Each individual of organization integrate individual RM process together

1. **Methods to be used in different risk Management Process**

Develop common perception of methods that will be used for different steps in risk management

2. **Definition of likelihood and impact scales**

Develop common understanding on likelihood of risks and consequences by negotiating and formal analysis

3. **In scope and out scope activities involved in RM**

Develop clear objectives and activities

Tools:

Risk Management Project Charter

- SIPOC
- Customer Orientation
- Customer or stakeholder Voice chart
- CTQ matrix
- CTB Matrix

- **Expected outcome & checklist**
- All RM team member's roles are identified
- All project participant possess the necessary information and resources for the project
- The capacity of team members for their project is ensured
- The team members know their roles and aware of their functions and responsibilities within the project
- RM process goals are formulated SMART
- Focus and scope, net benefit, milestones and project schedule are defined and agreed on

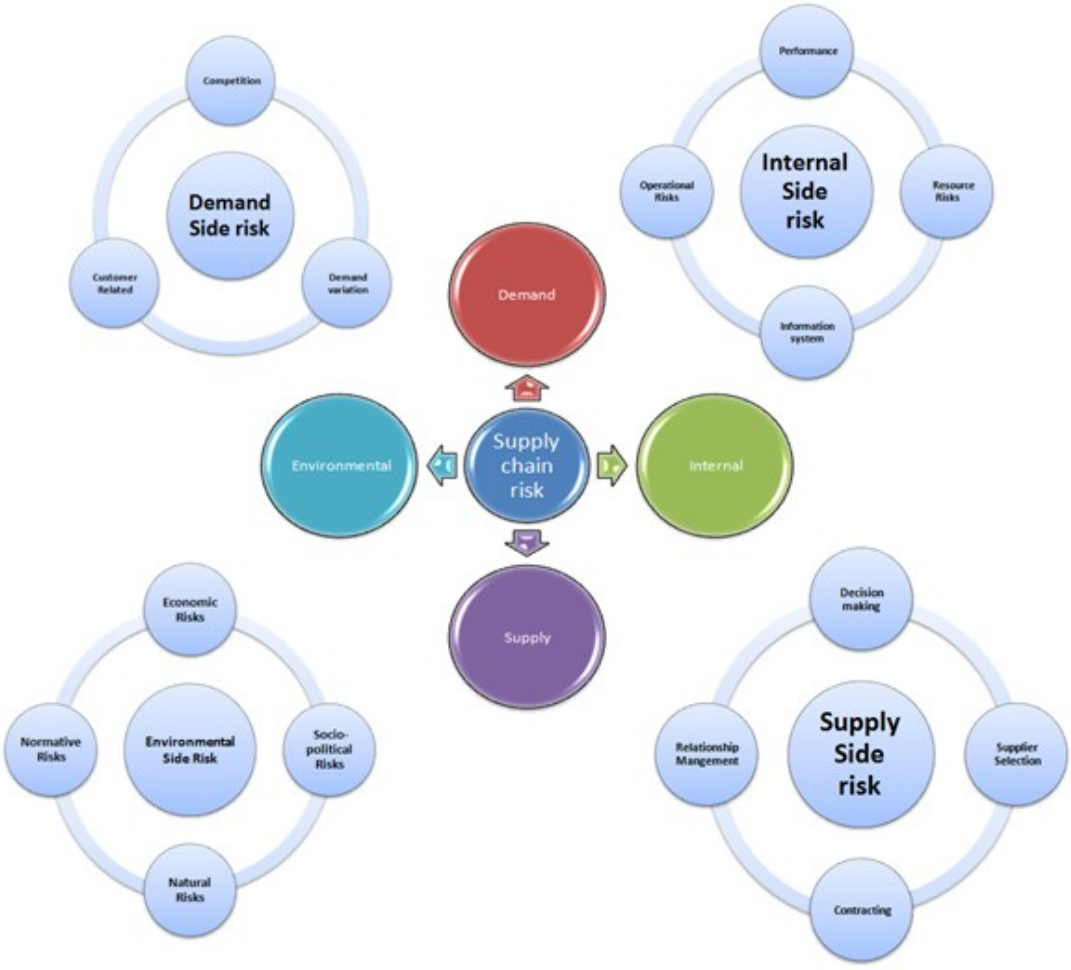
5.5.2.7 Delimitation of supply chain services scope

By delimiting the scope of risk management activities, the decision is made which elements of supply chain management is to include in risk management activities and which elements are not. The delimitation of the scope can for example be done along the following dimensions:

- Delimitation along the supply chain : what services are included in the analysis, what are not
- Delimitation along specific activities.

5.5.2.8 Delimitation of possible risk causes

Risk management activities have to be scoped further in term of risk causes and risk sources that are considered. By executing this scoping, the general structure and taxonomy of risk causes is also established in this step. The following figures clearly demonstrate main risk taxonomy of supply chain management.



5.5.2.9 Definition of objectives

In this step, the risk management effort has to be scoped in regard to the objectives of the Supply chain. As risk is the effect of uncertainty on objectives, it has to be made clear which objectives are considered. Examples of objectives and the associated risks are

- Risk of cost overrun due to cultural conflicts
- Risk of low performance due lacking of communication
- Risk of legal and regulatory problems because of process violation
- Risk of damage to process reputation due costing over runs

5.5.3 RISK IDENTIFICATION

The goal of risk identification is to develop a detailed list of risks that affect the objectives of Supply chain management. During this phase, the main risks within the scope of current analysis are identified and documented in a risk catalogue.

The risk identification process consists of four steps:

5.5.3.1 Visualization of a process

During the first step, all supply chain activities are visualized. Most effectively, the same type of visualization is used as was used during the delimitation of the services scope. The visualization serves the dual of purpose of confirming the prior scoping, as well as making sure that every person on the risk identification team has the same understanding of the tasks. After defining the overall supply chain, list each and every single nodes comprises of different suppliers, retailers, distributors and customers.

5.5.3.2 Analysis of value creation

1) In this step, the value creation is further analyzed and understood. The goal is to understand how the process contributes to the achievement of the overall objectives of the relationships. This may include the further decomposition of the process or the mapping of the relationship between the causal areas and the activities being analyzed.

5.5.3.4 Identification of Risk causes and consequences

During the identification of risk causes and consequences, the uncertain events are described both in terms of their causes as well as its impact on supply chain objectives.

5.5.3.5 Compiling of risk catalogue

The final step consists in compiling the findings into risk catalogue which is the basis for the following process steps (and will be updated continuously). This includes the description of uncertain event, the impact, a first description of the underlying causes as well as the possible impacts.

Various risk sources are identified with the help of literature review and is presented in table 14.

5.5.3.6 Tools/techniques approaches for Risk Identification

A variety of techniques are presented in the literature by academicians. Some of these tools are general that they can be used to identify any kind of risk such as brainstorming, cause and effect analysis, process mapping etc. Some are specific in nature used for supply chain such as supply chain mapping, critical path identification etc. The choice of appropriate tools depends upon the situation and circumstances. The most important technique used by in literature is method of surveying/questionnaire and interviews. Following article discussed (Jiang et al 2009), (Tuncel et al 2009), (X.Li&I.Barnes et al 2008), (Loosemore et al 2008), (Thun et al 2009), (A.oke et al 2009), (Tsai, M. C et al 2008), (Barbara et al 2006), (Breen, L. 2008), (A. Brun et al 2006), (Lim, S. H.et al 2009),(S.M.Wagner et al 2008),(Autry&Bobbit et al 2008). Another famous tool is dephi technique used by (Tsai, M. C et al 2008),(Hameri, A. P. 2009).

Table 13: Various risk sources

Shashank et al (2009)	External risk and Internal risk
Trkman(2009)	Endogenous risks and Exogenous risks
Manuj et al (2008a)	supply risks, demand risks and operational risks
Manuj et al(2008b)	Supply risks, demand risks, opertional risks, security risks, macro risks, policy risks, Competitive risks and resource risks
Gastaldi(2006)	Internal risks and External risks
P. W. Stonebraker(2009)	External risks, Internal risks and unanticipated /random risks
Wagner & Bode et al (2006)	Demand side risk, Supply side risk and Catastrophic risk
S.K.Cheng et al(2008)	organizational risk, infrastructure risk, Environmental risk and Delivery of services
S.M.Wagner et al(2008)	demand side risk, Supply side risk, regulatory, legal and bureaucratic risks, infrastructure risk and catastrophic risk
omera khan et al(2007)	Infrastructure, business control, business value and Relationship
A.oke et al(2009)	Supply risks, demand risks and Miscellaneous risks
Tobias et al (2008)	Product related, Partner related and environmental
Tang et al(2008)	Supply risk, Process risk, Demand risk, Intellectual property risk, Behavioral risk and political /social risk
Iwan et al(2009)	Operational accidents, Operational Catastrophe and Strategic uncertainty
Ritchie et al(2007a)	Environmental characteristic, Industry characteristic, Organization's strategy ,Problem specific decision making unit, supply chain configuration and supply chain members
Blos et al(2009)	Operational risks, disruptions risks, financial vulnerability, strategic vulnerability, hazard vulnerability and operations vulnerability
G.tuncel et al(2009)	Supplier, inbound /outbound logistics, manufacturer and customer
S.M. Wagner et al(2009-a)	Demand side, supply side and supply chain structure
Wu et al.(2006)	Internal and External
Jiang et al(2009)	Cost risks, operational risks and reputation risks
William (2006)	Low severity low likelihood, high severity low likelihood, low severity high likelihood and high severity high likelihood
Ritchie et al(2007b)	Primary level and secondary level
Jennifer et al(2008)	Disruption /Disaster, logistics, supplier dependence, quality, information system, forecast, legal, intellectual property, procurement ,receivable, capacity and
manuj et al(2008b)	Supply risks, demand risks and operational risks
C.-Y. Tsai et al(2008)	asset risk, relationship risk and competence risk
A.oke et al(2009)	Inherent or high frequent risks, disruption or infrequent risks and moderate impact risks

Another important risk identification tool is Action Research(AR) used by (Tobias 2008). Action research is a qualitative research technique in which the researcher actively participates in and influences ongoing organizational processes, but intermittently steps out of the system to obtain a broader perspective (Ottosson, 2003). The researcher can thus be described as an outside agent, taking action and creating knowledge at the same time, who acts as a facilitator in an organization (Coughlan and Coghlan, 2002). Some of the quality tools such as process mapping and cause and effect diagram are used by (Kumar, S 2008), (Kumar, S 2007) for identification puposes.The concept of simulation software used for identification is also gaining importance. Different real life Scenarios are simulated and risks are identified such as used by (Briano 2010-b).Another way of risk identification is to investigate different databases consists of Literature review, electronic resources and newspaper etc. such as done by (Hamid Mohtadi 2009). Supply chain vulnerability map is also useful in order to detect risks at supply chain level. (Blos et al 2009). Other tools used are expert opinion combined with historic data or combined with decision maker's opinion, Game theory , catastrophe modeling and real option approach(knemeyar 2009).

5.5.3.7 Summary of tools & brief illustration

Risk Register

The purpose of risk identification is to produce a list of the most significant risks to a supply chain, and this list is often described as a 'risk register' or 'risk portfolio'. This is a document – or more usually an entry in a risk database – that records the features of the risks. An initial format is illustrated in Figure **14.**

Summary			Description		
Identification number	Date recognized	Owner	Description of risk	Description of impact	Probability
1					
2					
3					
4					
5					

Fig 17: Risk Identification tool 1: Risk Register

'Five whys'

When some risky event has actually happened, the easiest way of identifying future risk is to repeatedly ask questions about the cause of the past event and find the likelihood that it will reoccur.

Cause-and-effect diagrams

This tool helps us to determine the relationship between risks and their causes often described as fish bone or Ishikawa diagram as well.

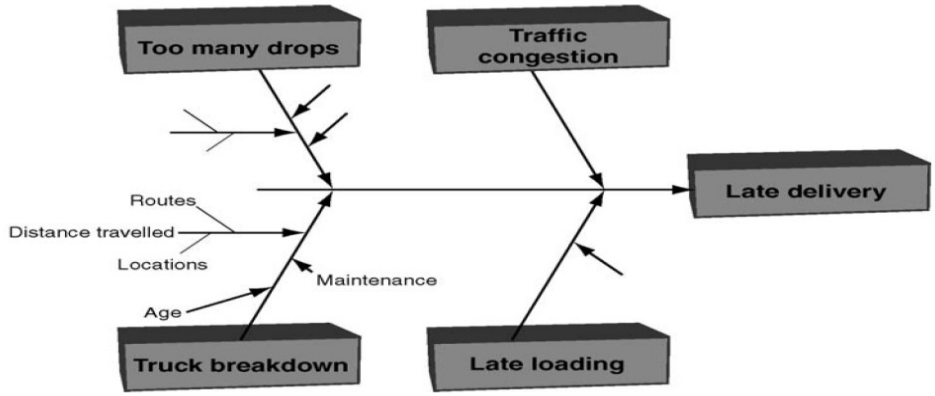


Fig 18: Risk identification tool Cause & Effect Diagram

Pareto Analysis

This is a frequency diagram of risky events based on the observation that 80 percent of the risks come from 20 percent of causes.

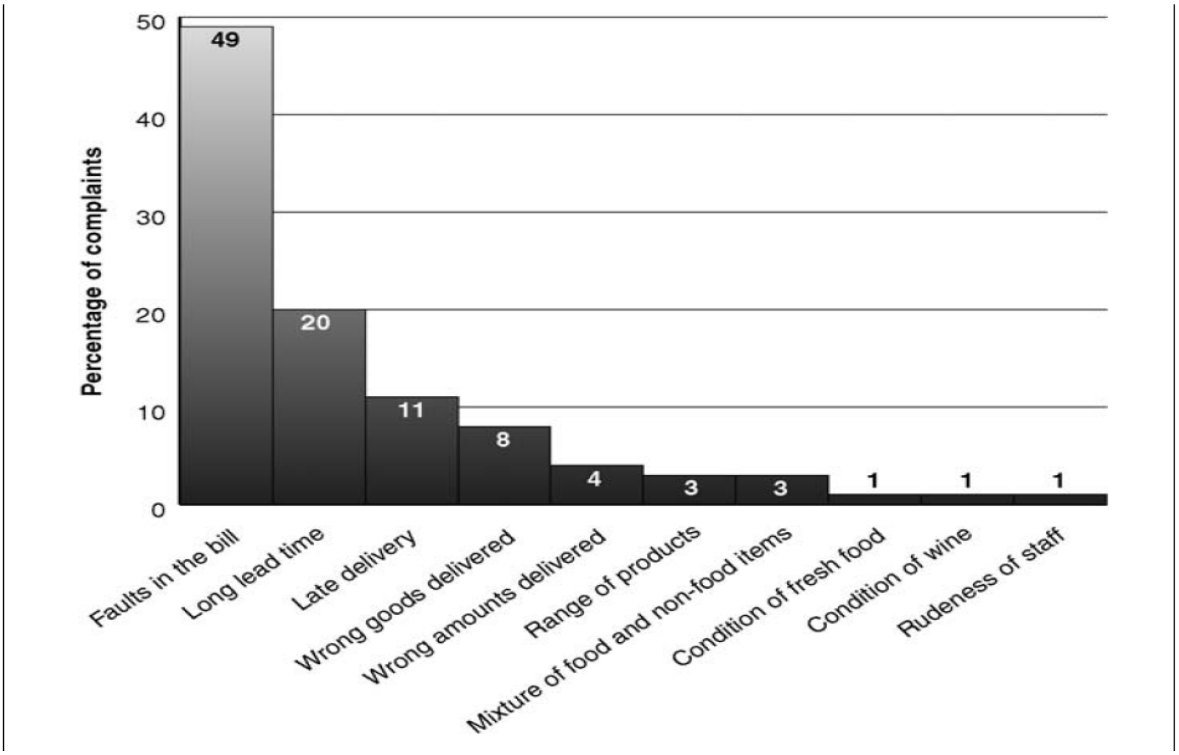


Fig19 : Risk identification tool Pareto Analysis

Brainstorming/Delphi Approach

One way to structure a brainstorming session is to ask everyone to focus on a single question or problem and then gather the input of participants in sequence around the table.

Design of Experiments

DOE can provide an unbiased, empirical method for root cause examination. It Undertake a systematic procedure in the sense of an efficient process analysis. The tool works out the relationship between the influencing factors in a process and the resulting product and process qualities with a minimal number of experiments. It also determines the optimal settings for establishing the response within the customer specifications.

Process Charts

With the help this tool, once can break down the supply chain operations into a series of distinct activities in order to identify the risks at each stage. After creating a full list for the whole supply chain, managers can study this list, critically analyze each activity and identify risks in each. Rather than start with a simple list, it is usually easier to describe a process in a diagram. There are several formats for this, with a basic one using a standard flow chart. A more formal process chart consists of following steps.

Operation – where something is actually done;

Movement – where products are moved;

Storage – where products are put away until they are needed;

Delay – where products wait for something to happen;

Inspection – to test the quality

Checklists

The knowledge of Common risks across a range of different operations in different organizations can be transferred through a checklist.

Supply chain event Management

SCEM is a rather broad term that describes different types of process control (Ansell and Wharton, 1995). The most common format uses structured brainstorming, where a group of experts systematically examine the operations of a supply chain to find deviations from planned performance. Then they investigate the deviations and find ways of eliminating their causes or take other actions to minimize the consequences. The principle here is that a systematic review will improve operations, reducing both variability and risk.

5.5.4 RISK ANALYSIS

This process is comprised of analyses phase where usually identified risk at previous stage are assessed not only to prioritize them in term of criticality but also to understand the relationship between various aspects such as checking interdependencies between risks and practices etc.

The risk analysis process consists of following steps

5.5.4.1 Developing Cause & Effect networks for the identified risks

The aim of the development of cause –and –effect networks for the identified risks is twofold: It allows for the systematic exploration and identification of the root causes of the identified risks, as well as extrapolating multiple types of impact. But even more importantly, it helps to aggregate the identified risks into an overall causal structure, allowing simplification and an increase in transparency by aggregating a number of risks into an overall risk networks.

5.5.4.2 Gathering data for the quantification of risk (likelihood and impact, or probability distribution)

In this step, the relevant data to quantify the risks is gathered. This can be done in a number of ways and to different levels of accuracy and detail. The qualitative understanding of the risk from the previous step allows for an informed decision making on the accuracy that is needed for the quantification, and thus the amount and accuracy of the needed data. Methods for data collection include for example

- Interviews and expert opinions
- Delphi study
- Lessons learned/ historical data from previous events
- Validated mathematical models
- External data (benchmarking data on comparable situations at other companies

5.5.4.3 Quantification of the risks

In this step, risks are quantified according to the guidance provided by stakeholders and with methods appropriate for the expected level of detail and reliability of the assessment. There are two approaches for risk evaluation. Qualitative and Quantitative

In qualitative approach, we consider different factors qualitatively such as nature of the risk with a qualitative description of the risk; consequences with a qualitative view of potential losses or gains; likelihood – giving a subjective view of whether the risk will materialize; However such measures usually lack of numerical value and hence sometime do not appear as attractive to management as compare to Quantitative.

All quantitative approaches are based on two factors 1) the probability of risk occurrences and 2) the impact of risk. So by definition it is

Risk = Probability X Impact

5.5.4.4 Compiling a list of quantified risks

In this step, risk catalogue is updated with the information on the quantification. The information from the quantification phase added to the risk catalogue should include

- Risk quantification
- Methods by which quantifications was obtained
- Data on which quantification was based
- Statement regarding the reliability of the accuracy of risk assessment (evaluation of the accuracy must depend on severity of the risk)

5.5.4.5 Tools for Risk Evaluation

The tools used for that purpose are very similar to risk identification phase, such as the delphi method or questionnaire/surveying etc. These techniques are used for assessment purpose by (M. Loosemore et al 2008) ,(P.Trkman et al 2009), (A.oke et al 2009), (Breen, L. 2008),**(Voss, M. 2009),** (Lim. S. H.et al 2009). The AHP is another method used to assess the criticalities affecting the objectives used by (Tobias 2008),(Tsai, M. C et al 2008),(Barbara et al 2006) and (Breen, L. 2008). Other qualitative tools use for assessment purpose are Risk matrix and risk register by (omera khan et al 2008-a) ,Probability impact matrix by (J.-H. Thun et al 2009) , Multi criteria scoring procedure and FMEA by (Jennifer et al 2008) and (G.tuncel et al 2009) respectively. Large organizations are using software tools in order to assess different risks when contracting and forecasting demands supply etc. Such as horizon demand scenario software, HP risk component cost forecasting and HP risk contract valuation software used by HP (Nagali, V.et al 2008). Simulation is no doubt an important way to assess the risk such as used by (Briano 2010-b) and (L. Jacxsens et al. 2009). Other important tools and ways found in the literature are extreme value theory used by (Hamid

Mohtadi 2009), , conjoint analysis used by (**Voss, M. 2009)** , probabilistic methods used by (**A. Brun et al 2006)** ,expert evaluation used by (Hameri, A. P. 2009) and supply chain vulnerability map used by (Blos et al 2009) Factorial Analysis/LOGIT by (Jiang et al 2009) , Petri net tool by (tuncel 2009).

5.5.4.6 Summary of tools and Brief Illustration

Approaches for finding risk probability

The probability of risk ranges from 0 to 1 where value close to 1 considers as high risk and similarly vice versa. There are three approaches used for calculating probabilities

1) Use knowledge of a situation to calculate a theoretical or a priori probability.
2) Use historical data to see how often an event actually happened in the past, and use this to give an experimental or empirical probability
3) People/experts subjective views about the likelihood of an event

Pareto Analysis

The tool is already briefly explained in previous section with figure.

Risk Map

It is useful to describe the categories of risk in a diagram that shows the relative seriousness and impact of risks. The most common format for this is a risk map. In risk map, the vertical axis shows the probability of events and the horizontal axis shows the consequences

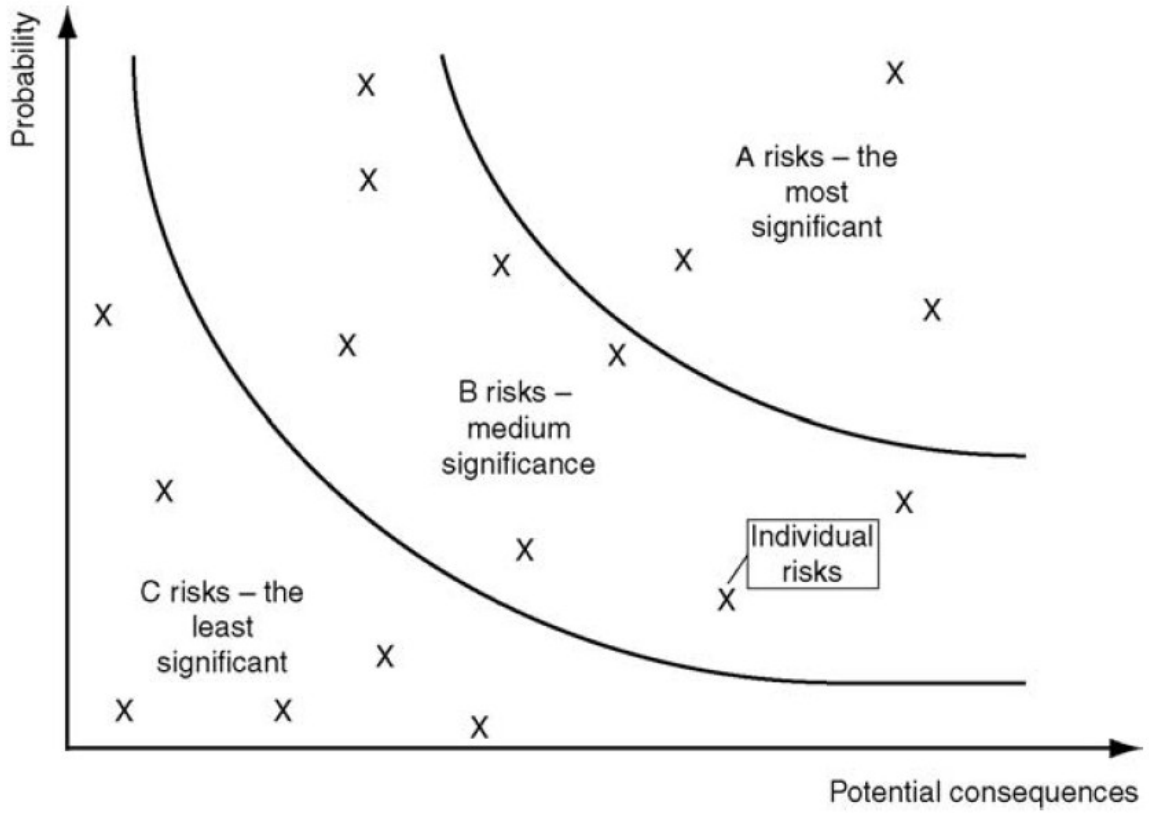


Fig 20: Risk Map

Probability Impact Matrix

A probability–impact matrix is also uses for describing classes of risk. It has essentially the same format as a risk map, but now we replace the actual values of probability and consequences by the more general categories. So the vertical axis shows probability categories and the horizontal axis shows categories of consequences. The result becomes a table rather than a graph, with descriptions of the risks put in the appropriate boxes in the body of the table.

		Potential consequences					
		Negligible	Minor	Moderate	Serious	Critical	Cata-strophic
Probability	Very high	B	B	A	A	A	A
	High	B	B	B	B	A	A
	Medium	C	B	B	B	A	A
	Low	C	C	B	B	A	A
	Very low	C	C	C	B	B	A

Fig 21: Probability Impact Matrix

FMEA

FMEA Identify causes and checks for potential weak points. It specifies priorities for the further analysis. It also Assess risks for the customer of a process and deduce measures for reducing risk.

#	Process Function (Step)	Potential Failure Modes (process defects)	Potential Failure Effects (KPOVs)	SEV	Potential Causes of Failure (KPIVs)	OCC	Current Process Controls	DET	RPN
1	Faculty Apply	Unable to use	unable to apply	9	System Unawareness	2	Administrator Help faculty	3	54
		Request sent back	Request delay	9	did not upload all requirements	8	Checklist for requiremnts	5	360
				9	unawareness of requirements	5	Checklist for requiremnts	5	225
		Request sent back	Request reject	9	Non-Eligibility	5	Eligibility check in many stages	1	45
2	Forward To Chairman	unable to approve	Request delay	9	System Unawareness	5	Administrator Help Chairman	3	135
				9	Chairman Busy	7	Receive Reminder	5	315
				9	Chairman out of office	5	No Action	1	45

Fig 22: an Excerpt of FMEA

Stage	Reference
Risk Identification	shashank and Thomas et al(2009), vanany,Zailani and Pujawan et al(2009), G.tuncel et al(2009), Ritchie et al(2007b), Achard, P. O.(2008), Nagali, V.et al(2008), Canbolat, Y. B.et al (2008), Jennifer et al(2008), J.-H. Thun et al, Tsai, M. C et al(2008), Kumar, S(2008), Deane et al 2010, Leopoulos, V.(2006), Breen, L. (2008), L. Jacxsens et al.(2009), A. Brun et al(2006), Hameri, A. P.(2009), Blos et al(2009), A.oke et al(2009), Wagner & Bode et al (2006), S.C. Ellis et al(2010), Autry&Bobbit et al(2008), Craighead et al(2007), C. Reade et al (2009), Micheli et al(2008), D. Elangovan(2009) Adhitya,A et al.(2007-a), Adhitya,A et al.(2007-b), M. Eric Johnson(2008), Samir Dani(2008), S. Pavlou(2008), Tobias et al (2008) , Jiang et al(2009), faisal et al(2007-a), Sami Kara(2008), Xia, D. et al 2010, Lockamy, A(2010), CHEN *et al.*(2010), Ma, H.,(2007), Chun-Ta Lin et al(2009), Oehmen, J.(2009), Thomas et al 2008, Klimov, R. (2008), Manuj et al (2008-a), Wu et al.(2006), Pujawan et al(2009), Jian Li(2007) , Ritchie et al(2007a), O.I. Aruoma(2006), A.M.Knemeyer et al(2009), Adhitya, A(2008), Berg, E.(2008), Wu, D. D. et al 2010, Hans-Peter Wiendahl(2008), Park, T(2007), Salmela et al 2010, Shanthakumar et al 2010, Adhitya,A.(2009), Lackes, R(2010), Foerstl et al 2010, Giannakis et al 2010, Agrawal et al 2010, Liebesman, S. (2008). Bob Ritchie et al 2010 , Gastaldi(2006), Lip Tse(2009), Zhang,Y.(2008), Yanjun, Z.(2009), Matook et al(2009),S.K.Cheng et al(2008), V.S.Rodrigues et al(2008), Ponomarov et al(2009), Smith, G. E.(2007), Pyke, D. et al 2010, Cigolini et al 2010 Farooq et al 2010
Risk Evaluation	vanany,Zailani and Pujawan et al(2009), G.tuncel et al(2009), Ritchie et al(2007b),P.Trkman et al(2009), Enyinda, C. I.(2010), ENRICO BRIANO(2010-b), S.M.Wagner et al(2008), Nagali, V.et al(2008), Canbolat, Y. B.et al (2008), Jennifer et al(2008), J.-H. Thun et al, Tsai, M. C et al(2008), Kumar, S(2008), L. Jacxsens et al.(2009), A. Brun et al(2006), Hameri, A. P.(2009), A.oke et al(2009), , S.C. Ellis et al(2010), D. Elangovan(2009),Adhitya,A et al.(2007-a), Adhitya,A et al.(2007-b), M. Eric Johnson(2008), S. Pavlou(2008), Tobias et al (2008) Kull et al(2008)Wei&Dong et al(2009)faisal et al(2006-a)Neureuther, B. D.(2009)? Faisal, M. N. (2009)Gaudenzi et al(2006)Moonis, M et al 2010Ganguly, K. K. (2009), faisal et al(2007-a), Sami Kara(2008), Xia, D. et al 2010, Lockamy, A(2010),R. Desbordes et al(2007)D.Bogataj et al(2007)F.T.S. Chan et al(2007) Ma, H.,(2007)S.M. Wagner et al(2009-a)A. Sarkar et al(2009)M.C. Wilson et al(2007)Miller, H. E. (2008)Hamid Mohtadi(2009), Oehmen, J.(2009), Thomas et al 2008, , Manuj et al (2008-a), Wu et al.(2006)Pujawan et al(2009), Jian Li(2007) , Ritchie et al(2007a), O.I. Aruoma(2006), A.M.Knemeyer et al(2009), Adhitya, A(2008)Berg, E.(2008), Wu, D. D. et al 2010, Hans-Peter Wiendahl(2008), Park, T(2007), Salmela et al 2010, Shanthakumar et al 2010Adhitya,A.(2009), Lackes, R(2010), Foerstl et al 2010, Giannakis et al 2010, Agrawal et al 2010, Liebesman, S. (2008). Bob Ritchie et al 2010 , Gastaldi(2006), Lip Tse(2009), Yanjun, Z.(2009), Matook et al(2009),S.K.Cheng et al(2008), , Ponomarov et al(2009), Smith, G. E.(2007), Pyke, D. et al 2010, Cigolini et al 2010

Table 14: Artcles address risk identification & risk evaluation

Scenario Analysis

Scenario analysis analyses the possible effects of a series of decisions. This is the same sort of approach as 'what-if ' analyses, but it tends to focus on larger problems and the longer term.

Simulation

Simulation goes further than scenario analysis and gives a detailed quantitative analysis of events that might occur. It uses a dynamic representation of a situation, with a computer model imitating real operations over a typical period. Usually real life situations models through simulation with the help of random data and results and outcomes are predicted.

Network Models

Supply chain is comprised of different nodes interconnected with each other with risk occurring through nodes or connections. Some specific types of models are maximal flow, transportation problems; shortest path set covering and facilities layout.

5.5.5 RISK EVALUATION

During risk evaluation, the decision is made for every risk whether it requires treatment, or whether it represents an acceptable risk.
The risk evaluation consists of the following steps:

5.5.5.1 Comparing quantified risk with defined thresholds

In this step, the level of risk determined during the risk analysis is compared to the acceptance thresholds that were set in establishing the context. The decision which risks are acceptable not only depend on the generated numbers but also on a careful evaluation of the context of the risks and an appraisal of the factors that were not captured by the quantification models

5.5.5.2 Ranking of risks

Risks are then brought into ranking according to the priority that was assigned to them. Risk ranking might be split according to areas of responsibility or by certain types of risks.

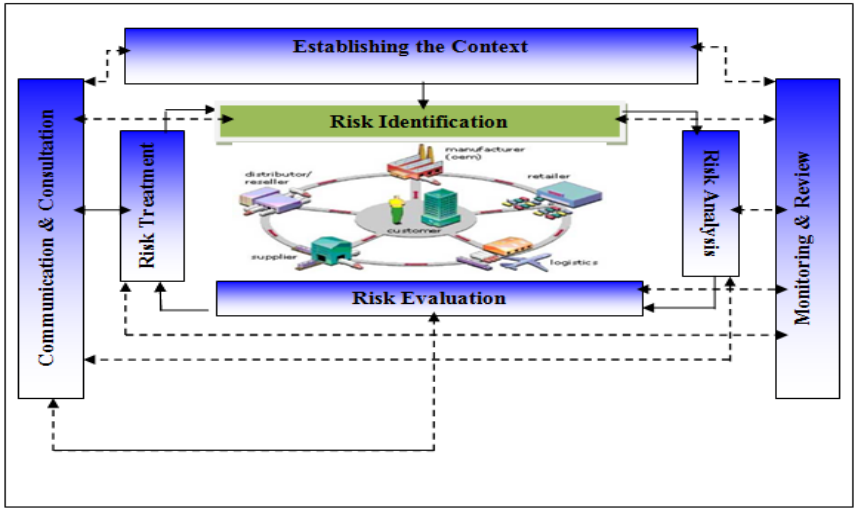
5.5.5.3 Selecting risks for treatment and Re-Analysis

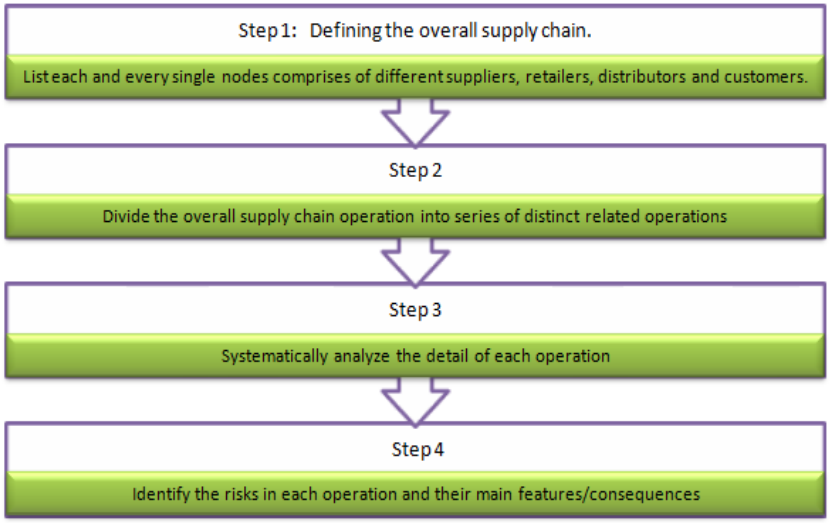
The selection for treatment must involve the relevant stakeholders as well as the people to whom the responsibility for the treatment will most probably be assigned. Decision makers may also discover during this step that current information on risk is insufficient.

5.5.5.4 Compiling list of risks for treatment

In this step, risk catalogue is updated with the information on which risks have been selected for treatment. This information should include

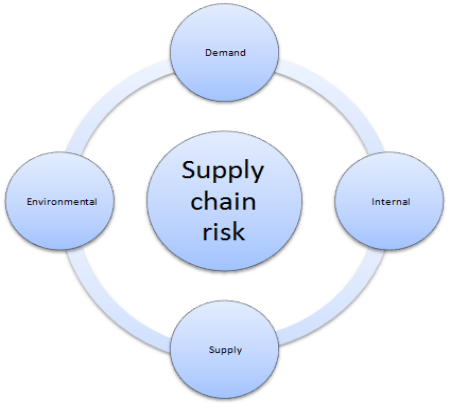
- Identification for risks for treatment
- Expected risk reduction
- Expected cost or effort for risk reduction





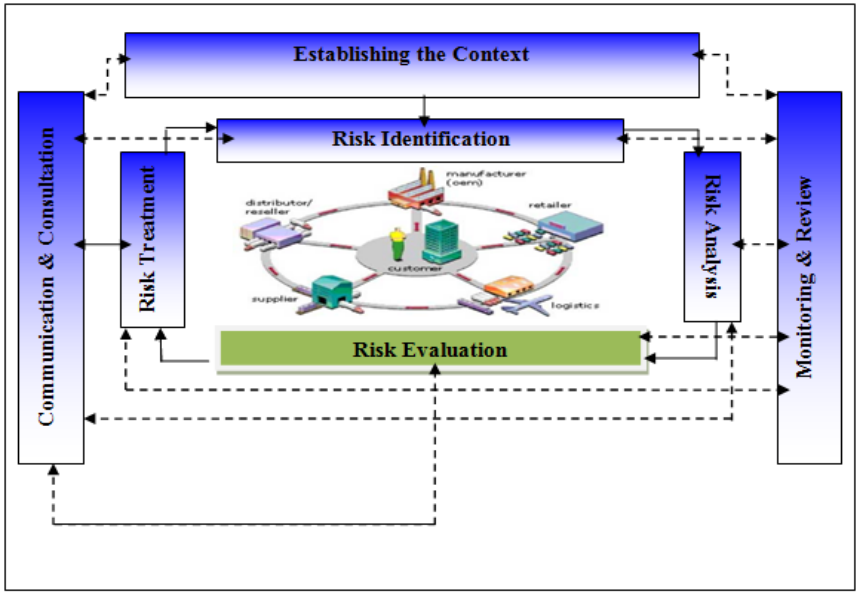
1) **Defining the overall supply chain.**
List each and every single nodes comprises of different suppliers, retailers, distributors and customers.
2) **Divide the overall supply chain operation into series of distinct related operations**
Such as logistics, IT, manufacturing, inventory

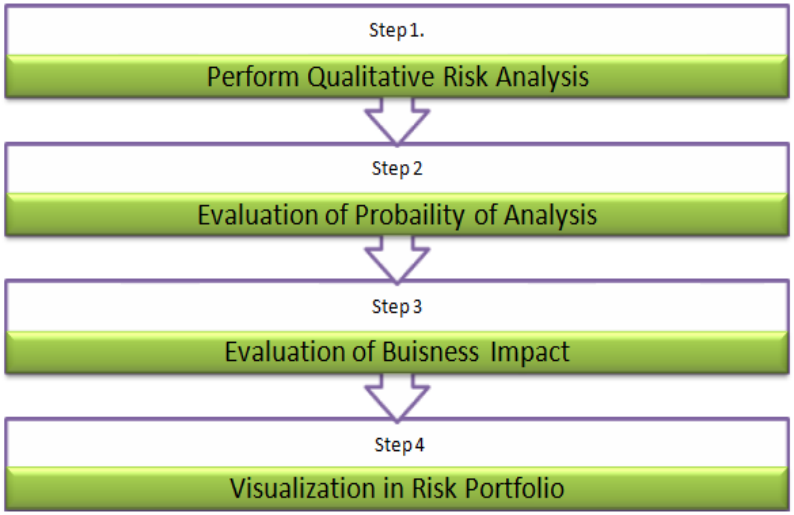
3) **Systematically analyze the detail of each operation**
Using tools, list each and every possible detail of operations, their inter relation as well
4) Identify the risks in each operation



Expected outcome & Checklist
Clear understanding of overall supply chain
Different supply chain operations are divided and analyzed fully
Risks are identified systematically by considering all sides
Most significant risks are compiled

Tools:
Risk Register
5 Whys
Cause & Effect diagram
Pareto Analysis
Brainstorming/Delphi approach
Design of experiments
Process chars
Checklists
Supply chain Event Management





1) Perform Qualitative Risk Analysis

Develop understanding of nature of risk and its effects and consequences

Nature of risk: qualitative description of risk

Consequences: with a qualitative view of potential loss or gains

Likelihood: subjective view of whether risk will materialize

Scope: area effected such as suppliers, deliveries,

Stakeholders: people affected by risk

Perform Quantitative Risk Analysis

Likelihood of risky event:

- Use knowledge of a situation to calculate a theoretical or a priori probability.
- Use historical data to see how often an event actually happened in the past, and use this to give an experimental or empirical probability
- People/experts subjective views about the likelihood of an event

Consequences when risk occurs

Relate the consequences of to the extent that they affect the organizational ability to achieve its aim

Put a value in consequences by

Rephrasing it in terms of cost (gain or loss)

Or in terms of time such as project completion time

Tools

- Pareto Analysis
- Risk Map
- Probability Impact Matrix
- FMEA
- Scenario Analysis
- Simulation
- Network Models

Expected Outcome

- Complete Understanding of risks and impacts
- Ordered level of risks and concern for each other
- Agreed risk register by all stakeholders

5.5.6 RISK TREATMENT:

This phase encompasses all activities that are concerned with the selection and execution of treatment measures for risks above the thresholds. It consists of following steps.

5.5.6.1 Analysis of management level and possible actions

In this step alternative treatments to reduce risks are collected. This step can be informed by the root cause analysis of the risk to demonstrate possible points of intervention regarding its occurrence or by the description of its impact to identify possibilities to minimize its damage. Fundamentally following classes of actions exist.

5.5.6.2 Analysis of impact of actions on event

In this step, the identified alternative options have to be analyzed regarding their impact on risks as well as impact on other stakeholders. For example, risk transfer is comparatively easy in a single firm, simply by agreeing a transfer of risk to another partner. But this now becomes more difficult, as we want to transfer risks somewhere that will reduce the level of risk for all members and not just shuffle the risk around trading partners.

5.5.6.3 Cost benefit analysis of treatment options and decisions

The analysis is followed by cost assessment resulting in a cost benefit analysis for every treatment options. Based on that, best treatment or combination of treatments is selected.

5.5.6.4 Compiling of treatment plan

Here, a treatment plan is compiled. This treatment plans outlines the actions that have been decided. It should contain following information

- Description of addressed risks
- Description of treatments
- Expected benefit of treatment
- Expected cost of treatment
- Timeline for implementation
- Responsibility for execution

Risk treatment strategies are either proactive or reactive in nature. In other words, either we take mitgative actions to address the risk sources or we take contingent action to address the risk consequences. While literature surveying, it has been observed that some papers do propose generalized strategies to address the risks. Such as postponement, speculation, Hedging, control/Share, and security (manuj 2008-b)) and some articles present specific to situation. For example use of reputed auditors for regulation compliance. (Ms Sodhi 2007). Some strategies were proposed based on the results of Modeling such as multi criteria optimization tool by which supplier can be selected based on customer sensitivity and risk alleviation dimension (Faisal et al 2006-a).Presenting all the solution in a single shot is out of scope of the paper however, readers are referred to tables of summaries for case studies, modeling and simulation and conceptual sections.

5.5.7 MONITORING & REVIEW

The monitoring and review process oversee both the risk situation of the organization, as well as the execution of the risk management process itself. It consists of four parts.

5.5.7.1 Monitoring the risk situation

The first set of activities monitors the overall risk situation. This may involve monitoring sub critical risks as well as risk currently being treated. The monitoring must define the frequency in which the risk assessments are updated, either globally for all risks, or in particular for exceptionally critical risks. The stakeholder may define their information need in the communication and consultation plan.

Table 15:Summary of issues and Risk Management Strategies discussed in Case-studies

Author	Issue	RM Strategy
G.Tuncel et al 2009	Risk modeling, designing, analyzing and evaluating supply chain	Petri net approach simulation
Tobias et al (2008)	Outsourcing decision Risk sources	Integration of AHP and Action research method
X.Li&I.Barnes et al(2008)	Supply risk management	conduction of supplier questionnaire covering a wide range of business dimensions of the supplier; performing a technical review; negotiating a risk mitigation plan; employing local based procurement staff; using a total cost estimate; applying a strict part qualification process
R R.Levary et al(2008)	Supplier selection	AHP
Chris Ellegaard et al(2008)	Supply risk management	knowledge protection and local sourcing, fairness and loyalty, responsiveness, dependable and like minded suppliers.
A.S. Oyegoke et al(2008)	Achieving agility to manage risks	the involvement of the agile specialists
M. Loosemore et al(2008)	Common perception of risks	communication, consultation and involvement in contractual decision-making
MS Sodhi(2007)	Managing risks	Design responsive supply chain building various forms of reserves including inventory, capacity, redundant suppliers and responsiveness Make to order and Make to forecast
S.M. Wagner et al(2009-b)	Supplier default dependencies	supplier development with relationship specific investment and upgrade supplier's performance, creation of a backup supply base of independent suppliers such as located at different parts of worlds etc.
Canbolat, Y. B. et al 2008	Supply risk analysis	FMEA and simulation tool
Jennifer 2008 et al	Risky products/parts and supplier	Author proposed a methodology based on multi criteria scoring method
P.Trkman et al(2009)	Exogenous and endogenous uncertainty	Closer relationship with suppliers
Ojha&gokhale et al(2009)	Managing risks	Logistic Business Continuity Planning
Kumar, S(2008)	Cargo theft	Six Sigma
Enyinda, C. I.(2010)	Managing risk	Risk reduction and risk avoidance
Blos et al(2009)	Supply chain vulnerability	better supply chain communication, SCRM & BCM training program and CRO creation
Craighead (2007)	Density, criticality and complexity of supply chain	Recovery and Warning
Omera khan et al(2009)	Supply chain risk	Design led products, 4c approach for transformation of traditional structure to design centric structure, champion for product range, cross functional team, cooperation in the extended enterprise and co-location of concurrent design teams
Lim, S. H.et al(2009)	Managing Risk	RFID
A. Mendes Primo(2010	Supply risks	Trust and power mechanisms internal integration between purchasing and manufacturing groups, customer integration
Leopoulos et al(2006)	Risks in Pharmaceutical supply chain	Electronic alliance
Laeequddin et al(2009)	SCRM in food sector	Trust building process
L. Jacxsens et al.(2009)	Climate change and globalization	Knowledge based modeling system
A. Brun et al(2006)	Use of IS in planning	Propose an information system
R. Masson et al(2007)	Agile supply chain	market sensitivity, postponement activities and collaborative information-sharing partnerships
Micheli et al(2008)	Supply risk management	project orientation in supply management, use of partnerships with suppliers, corporate standardizations and need of co design.
D. Elangovan(2009)	Time delay	Efficient responsive SCRM model
Adhitya,A et al.(2007)	Optimal schedule, disruption in schedule	heuristic rescheduling strategy
Samir Dani(2008)	Risk identification & treatment	the concept of agility and scenario planning for risk management

Author	Issue	RM Strategy/approach
Wu et al (2006)	Supply side risk	AHP
Gaudenzi et al(2006)	Risks involve in SC objectives	AHP
F.T.S. Chan et al(2007).	Risk involve in supplier selection	AHP+ fuzzy logic
Kull et al(2008)	Risk free supplier selection + SC objective	AHP+ goal programming
Ganguly, K. K. (2009)	Risk assessment	Pattern matching approach
Ma, H.(2007)	Risk evaluation	Fuzzy sets+ influence diagram theory
Zhang,F.(2006)	Risk prediction + Forecasting improvements in Supply Chain	Linear dynamic system consists of Gaussian noise assumptions+PCA
Miguel Laínez, J.(2009)	Supply chain risk	Product development activities should be synchronized and coordinated Multi stage mixed integer LP model
Anna Nagurney(2006)	Profit maximization+risk minimization	NLP model
M. Goh et al.(2007)	Profit maximization+risk minimization	proposed an algorithm based on stochastic model that maximize the profits while minimizes the risks using Moreau-Yosida regularization
Eleftherios et al(2010)	Tradeoff between inventory policies and supplier disruption risk	propose a single period stochastic inventory decision-making model
Chandra A. Poojari(2008)	Resource allocation along risks considerations	two stage stochastic Integer programming model
Fengqi You(2009)	Decision making + resource allocation	two-stage stochastic linear programming model
Deniz, E.(2008)	Optimization of Net present value of cash flow along risks and uncertainties	stochastic programming and mixed integer programming approach
J.K.Deane et al(2009-b)	Quantification of IT security risks	generalize mathematical model
Wang et al(2009)	Optimal facility location along with risks	an integer programming approach
A. Sarkar et al(2009)	Optimal no of supplier with supplier risk considerations	Mathematical model
fuzzy multi objective programming approach	Supplier selection	fuzzy multi objective programming approach
Wu et al (2008)	Supplier risk evaluation	Comparing chance constraint programming, data envelopment analysis and multi objective programming
Faisal et al(2006-a) **Faisal, M. N. (2009)**	Mapping supply chain on different dimensions	graph theory approach
Neureuther, B. D.(2009)	Risk assessment	Risk assessment index
A.J. Ruiz- et al(2007)	to determine optimal no of suppliers during the presence of supplier failure risks.	decision tree approach sole sourcing , additional suppliers
Faisal, M. N(2007-b)	Models variable associated with environment along their interdependencies	framework based on graph theory and matrix methods
Lee, T. Y. S. (2008) to	determine the optimal set of suppliers	proposed mean-variance approach
C.S. Tapiero et al(2007)	quality control in supply chain	provided a quantitative model based on Neyman pearson statistical risk framework with economic considerations.
Recently, Lockamy, A(2010)	Supplier Risk assessment	risk profile based on Bayesian network
***Chen et al.*(2010)**	Outsourcing decision with risk considerations	sourcing decisions based on Bayesian information are more effective than based on static information
Jiang et al (2009)	Root causes of job dissatisfaction	new enterprise level HRM practices such as performance based compensation, training and emphasizing commitment and implement POM practices , International buyers can cooperate with suppliers to improve labor conditions by giving financial award to those reduce employee turnover ,educating the suppliers about advantages of stable work force and its impact on supply chain Government can also play role on this by encouraging local companies to consider employee retention
S.M. Wagner et al(2009-a)	Risk analyze and interdependencies	graph theory approach
faisal et al(2007-a)	Risks of transaction cost	Effective and efficient information flow information sharing among SC partners, support to partners and incentive alignment etc
Jing Hou et al (2009)	Effect of backup supplier during disruptions	a quantitative model that would help to determine the optimal order quantity assigned to back up suppliers when supply risk consider
Wei&Dong et al(2009)	Risk assessment	Input output model
Tomlin(2009)	Link between Risks and strategies	Contingent sourcing, supplier diversification
***H. Yu et al*(2009)**	Impact of risks on outsourcing decision	Single sourcing, dual sourcing
	How much flexibility is needed	Examination of Strategies from literature

Sunil Chopra (2007)	Recurrent supply risk and disruption risk	decoupling recurrent supply risk and disruption risk when planning appropriate mitigation strategies
J.K.Deane et al(2009-a)	Risks in supply base	tool based on multi criteria optimization
D.Bogataj et al(2007)	Risk measurement	input output analysis and laplace transforms
Maria C. Carneiro(2010)	Optimal design of portfolio in supply chain	framework of two-stage stochastic programming and applying the conditional value-at-risk (CVaR)
A.Azaron et al.(2008)	Sc design under uncertainty	multi-objective stochastic programming
Chun-Ta Lin et al(2009)	Optimal routing and inventory planning	hedge-based coordinated inventory replenishment and shipment (HORS) methodology
Oehmen, J.(2009)	Cause and effect of SC risks and dynamics of risk development	A Supply Chain Risk Structure Model ,the Supply Chain Risk Dynamics Model
Liang-Chuan et al(2009)	Supplier selection under uncertainty	Switching option approach
Sami Kara(2008)	Risk factors simulation	system dynamics approach
Abdelkafi, C.(2009)	Forecasting improvement	use Bayesian approach
D.Neiger et al(2009)	Risk identification	Value focused process reengineering

Table 16: Summary of issues and Risk Management strategies discussed in Modeling/Simulation

S.K.Cheng et al(2008	**Analyzing complexities**	**a conceptual framework using the Principal Agent concept**
G.T.Stewart et al(2009	Community resilience	community resilience framework
Pettit, T(2010)	Assessment of SC vulnerabilites	conceptual framework
	SC enterprise risks	risk sharing, information sharing, change of inventory control mode, and supply chain flexibility.
Yang, B.(2010)	C complexity	Postponement
Smith, G. E.(2007)	Information risk	conceptual framework
P. W. Stonebraker(2009)	Assessment of SC risks	a diagnostic process that can be used in brainstorming and decision-making processes by senior management
R.A. Dowty et al(2009)	SCRM	Organizational culture
Braunscheidel et al (2009)	Agility	a conceptual framework

Table 17:Summary of SCRM strategies used in/ proposed in Conceptual section

5.5.7.2 Review execution of risk management process

This step ensures that risk management process is executed according to defined standards. This includes the quality in which the process is executed, the adherence to the guidance set by stakeholders, as well as the frequency of the execution.

5.5.7.3 Monitor implementation of risk treatment actions

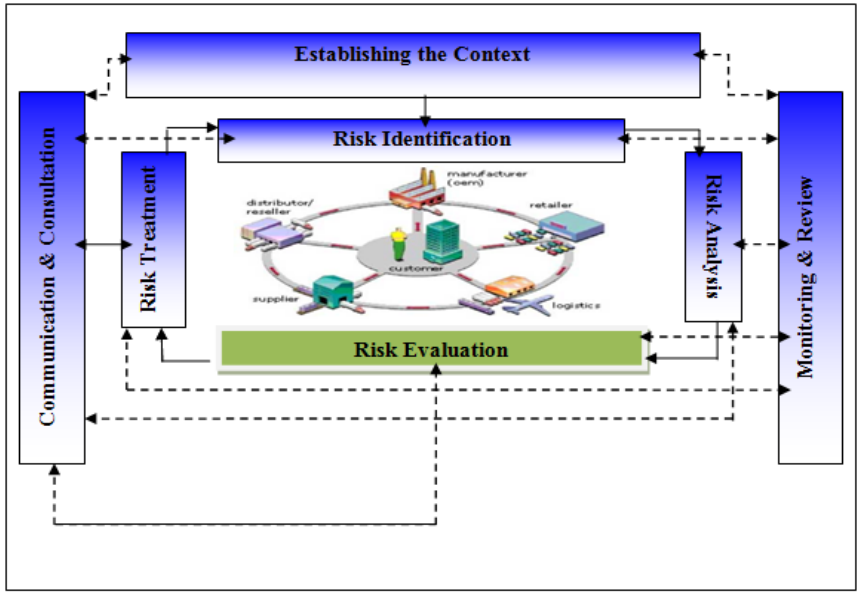
Here, we ensure that treatments that have been decided upon are executed in the defined fashion and within the time frame. This may also involve re-assessment of a risk after a treatment has been completed, in order to determine if risks is still critical and follow on actions necessary.

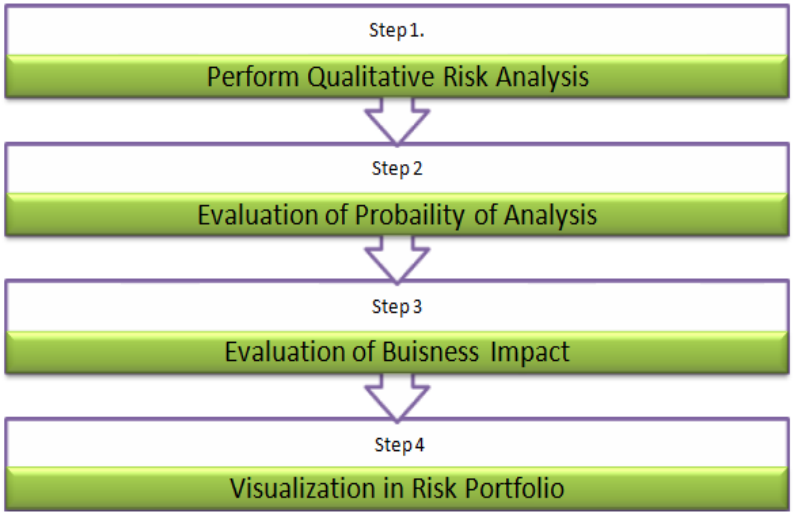
Supplier Risk Management	Tang et al(2006), shashank and Thomas et al(2009) ,Peck et al (2006), David et al 2010, Ou Tang et al 2010, vanany,Zailani and Pujawan et al(2009), G.tuncel et al(2009), Ritchie et al(2007b), Achard, P. O.(2008), Nagali, V.et al(2008), MS Sodhi1(2007), P.Trkman et al(2009), J.-H. Thun et al, Leopoulos, V.(2006), ENRICO BRIANO(2010-b), A. Brun et al(2006), Blos et al(2009), S.M.Wagner et al(2008), S. Pavlou(2008), Tang et al(2008), Sami Kara(2008), D.Bogataj et al(2007), Manuj et al (2008-a), Pujawan et al(2009), Ritchie et al(2007a), A.M.Knemeyer et al(2009), Bhat, S. K. S. a. A. (2009), Enrico Briano(2010), V.S.Rodrigues et al(2008), Ponomarov et al(2009), Choi, et al 2006, Farooq et al 2010, Pyke, D. et al 2010, Erik et al 2011. Wu,X.(2006), Yang, B et al 2010, S.K.Cheng et al(2008), Matook et al(2009), Foerstl et al 2010, Salmela et al 2010, Wu et al.(2006), D.Neiger et al(2009), D. Wu et al(2008), Abdelkafi, C.(2009), Denis R. Towill(2008), Cigolini, R(2006), Colicchia et al 2010, Thomas et al 2008S, M.C. Wilson et al(2007), H. Yu et al(2009), a.Sarkar et al(2009), S.M. Wagner et al(2009-a), Wang et al(2009), T. Xiao et al (2009), sawik et al 2011, J.K.Deane et al(2009-a), Haleh, et al 2010, Sting, F. J. et al 2010, Brian Tomlin(2006), Talluri, S. et al 2010, Sunil Chopra(2007), Deniz, E.(2008), CHEN et al.(2010), Volodymyr Babich(2007), Lockamy, A(2010), Xiaoyan et al 2010, Anna Nagurney(2006), Wang, Y et al 2010, Lee, T. Y. S. (2008), Babich(2006)
Demand Risk Management	Tang et al(2006), shashank and Thomas et al(2009) ,Peck et al (2006), David et al 2010, Ou Tang et al 2010, vanany,Zailani and Pujawan et al(2009), G.tuncel et al(2009), Ritchie et al(2007b), Achard, P. O.(2008), Nagali, V.et al(2008), MS Sodhi1(2007), P.Trkman et al(2009), J.-H. Thun et al, Leopoulos, V.(2006), ENRICO BRIANO(2010-b), A. Brun et al(2006), Blos et al(2009), S.M.Wagner et al(2008), S. Pavlou(2008), Tang et al(2008), Sami Kara(2008), D.Bogataj et al(2007), Manuj et al (2008-a), Pujawan et al(2009), Ritchie et al(2007a), A.M.Knemeyer et al(2009), Bhat, S. K. S. a. A. (2009), Enrico Briano(2010), V.S.Rodrigues et al(2008), Ponomarov et al(2009), Salmela et al 2010 D.Neiger et al(2009), D. Wu et al(2008), Denis R. Towill(2008), A. Sarkar et al(2009), S.M. Wagner et al(2009-a), Wang et al(2009), Deniz, E.(2008), P. Aggarwal(2007), Xiaoyan et al 2010, Anna Nagurney(2006)
Internal Risk Management	Tang et al(2006), shashank and Thomas et al(2009) ,Peck et al (2006) David et al 2010, Ou Tang et al 2010, vanany,Zailani and Pujawan et al(2009), G.tuncel et al(2009), Ritchie et al(2007b), Achard, P. O.(2008), Nagali, V.et al(2008), MS Sodhi1(2007), P.Trkman et al(2009), J.-H. Thun et al, Leopoulos, V.(2006), ENRICO BRIANO(2010-b), A. Brun et al(2006), Blos et al(2009), S.M.Wagner et al(2008), S. Pavlou(2008), Tang et al(2008), Sami Kara(2008), D.Bogataj et al(2007), Manuj et al (2008-a), Pujawan et al(2009), Ritchie et al(2007a), A.M.Knemeyer et al(2009), Bhat, S. K. S. a. A. (2009), Enrico Briano(2010), V.S.Rodrigues et al(2008), Ponomarov et al(2009), Wu,X.(2006), Pyke, D. et al 2010, Salmela et al 2010, D. Wu et al(2008), S.M. Wagner et al(2009-a)
Environmental Risk Management	Tang et al(2006), shashank and Thomas et al(2009) ,Peck et al (2006), David et al 2010, Ou Tang et al 2010, vanany,Zailani and Pujawan et al(2009), G.tuncel et al(2009), Ritchie et al(2007b), Achard, P. O.(2008), Nagali, V.et al(2008), MS Sodhi1(2007), P.Trkman et al(2009), J.K.Deane et al(2009-a),J.-H. Thun et al, Leopoulos, V.(2006), ENRICO BRIANO(2010-b),A. Brun et al(2006), Blos et al(2009), S.M.Wagner et al(2008),S. Pavlou(2008), Tang et al(2008), Sami Kara(2008), A. Sarkar et al(2009)D.Bogataj et al(2007), Manuj et al (2008-a), Pujawan et al(2009),Ritchie et al(2007a), A.M.Knemeyer et al(2009),Bhat, S. K. S. a. A. (2009), Enrico Briano(2010), V.S.Rodrigues et al(2008), Ponomarov et al(2009), Sunil Chopra(2007), Deniz, E.(2008), P. Aggarwal(2007)

Table 18: articles address different risk sources & management

5.5.7.4 Trigger and monitor corrective actions

The last and final step deals with triggering and monitoring of corrective actions. These may involve changes to the risk management process, the re identification of risks in certain intervals or after major changes in the relationship.





2) Perform Qualitative Risk Analysis

Develop understanding of nature of risk and its effects and consequences

Nature of risk: qualitative description of risk

Consequences: with a qualitative view of potential loss or gains

Likelihood: subjective view of whether risk will materialize

Scope: area effected such as suppliers, deliveries,

Stakeholders: people affected by risk

Perform Quantitative Risk Analysis

Likelihood of risky event:

- Use knowledge of a situation to calculate a theoretical or a priori probability.
- Use historical data to see how often an event actually happened in the past, and use this to give an experimental or empirical probability
- People/experts subjective views about the likelihood of an event

Consequences when risk occurs

Relate the consequences of to the extent that they affect the organizational ability to achieve its aim

Put a value in consequences by

Rephrasing it in terms of cost (gain or loss)

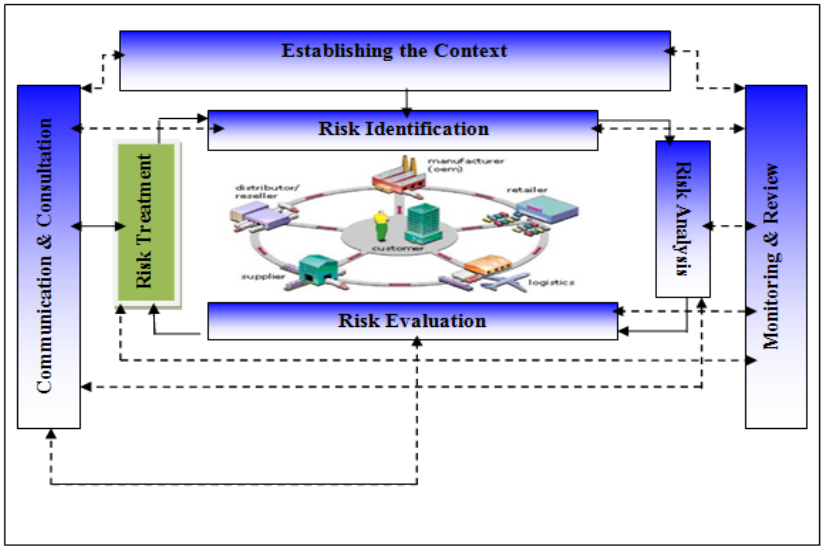
Or in terms of time such as project completion time

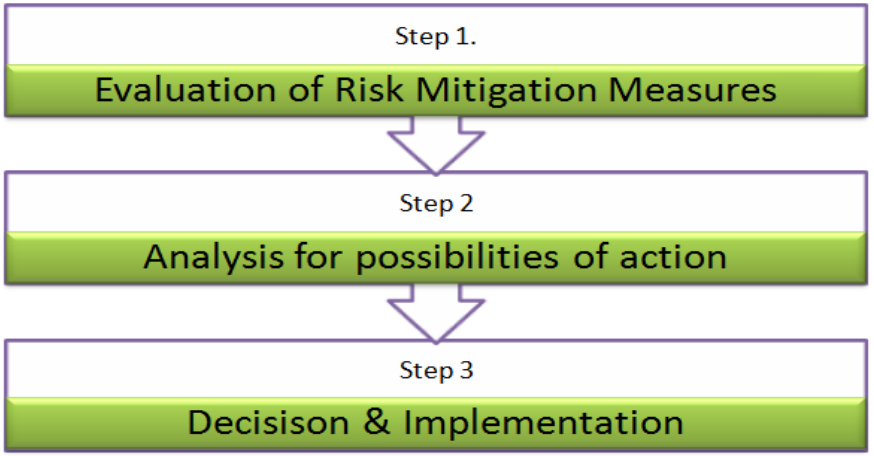
Tools

- Pareto Analysis
- Risk Map
- Probability Impact Matrix
- FMEA
- Scenario Analysis
- Simulation
- Network Models

Expected Outcome

- Complete Understanding of risks and impacts
- Ordered level of risks and concern for each other
- Agreed risk register by all stakeholders





Evaluation of Risk Mitigation Measures

- It involves balancing the costs and efforts of implementation against the benefits.
- It is also important to consider the values and perceptions of stakeholders

Analysis for possibilities of actions

Decision & Implementation

- Reasons for strategy selection
- Selection of accountable persons for specific tasks
- Performance measure and constraints
- Reporting and monitoring requirements
- Timing and schedule

Evaluation of Risk Mitigation Measures

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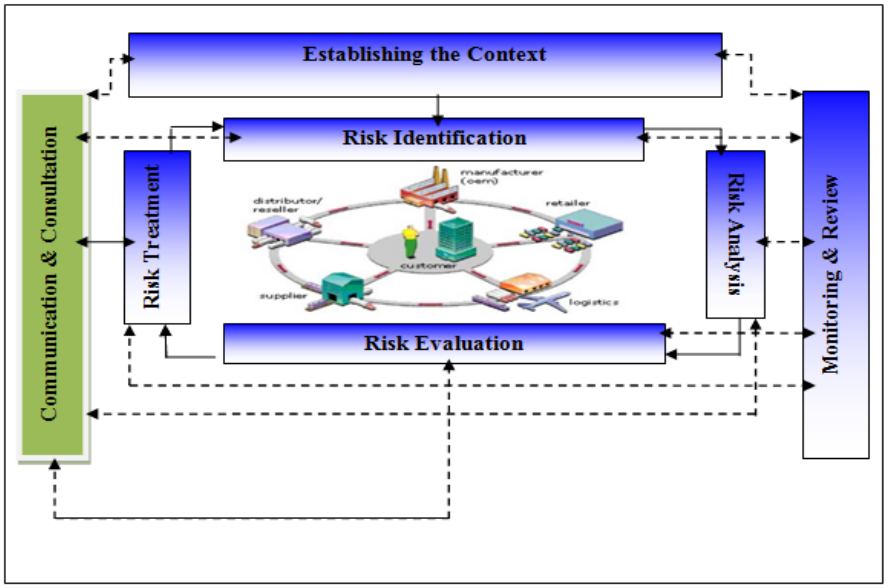
- Selection of accountable persons for specific tasks
- Performance measure and constraints
- Reporting and monitoring requirements
- Timing and schedule

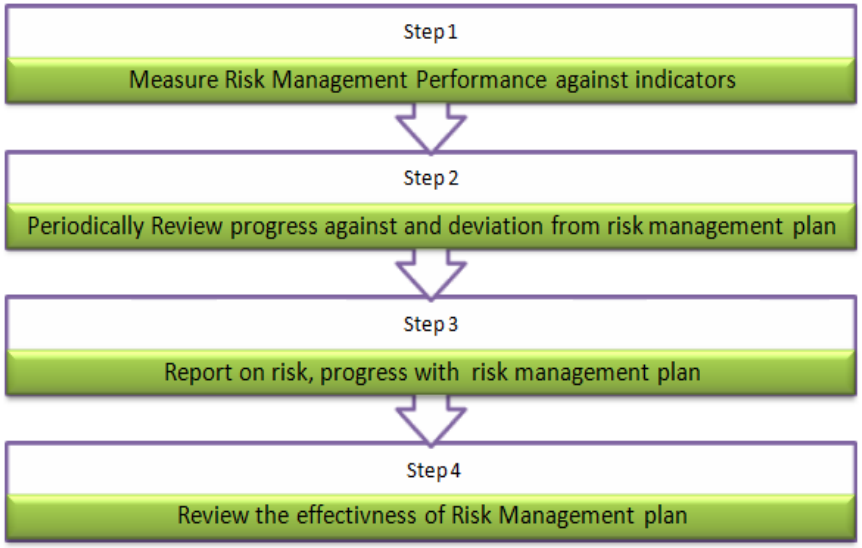
Expected Outcomes

Complete agreement between all stakeholders for risk mitigation measures

Responsibilities and actions are clearly assigned to each stakeholder

Reporting and evaluation mechanism aere clearly communicated





Checklist
Ensure that the measurements are standardized and institutionalized.
Secure the communication of the process, i.e. that others can access it.
Process documentation covers the entire process flow by taking into consideration the responsibilities, the working methods, and interfaces beneath the process level
Inform about the day-to-day performance at a glance.
Recognize deviations from standards in an easy way.

Tools

- Process Documentation
- Monitoring / Control Charts
- Reaction Plan / Process Management Diagram

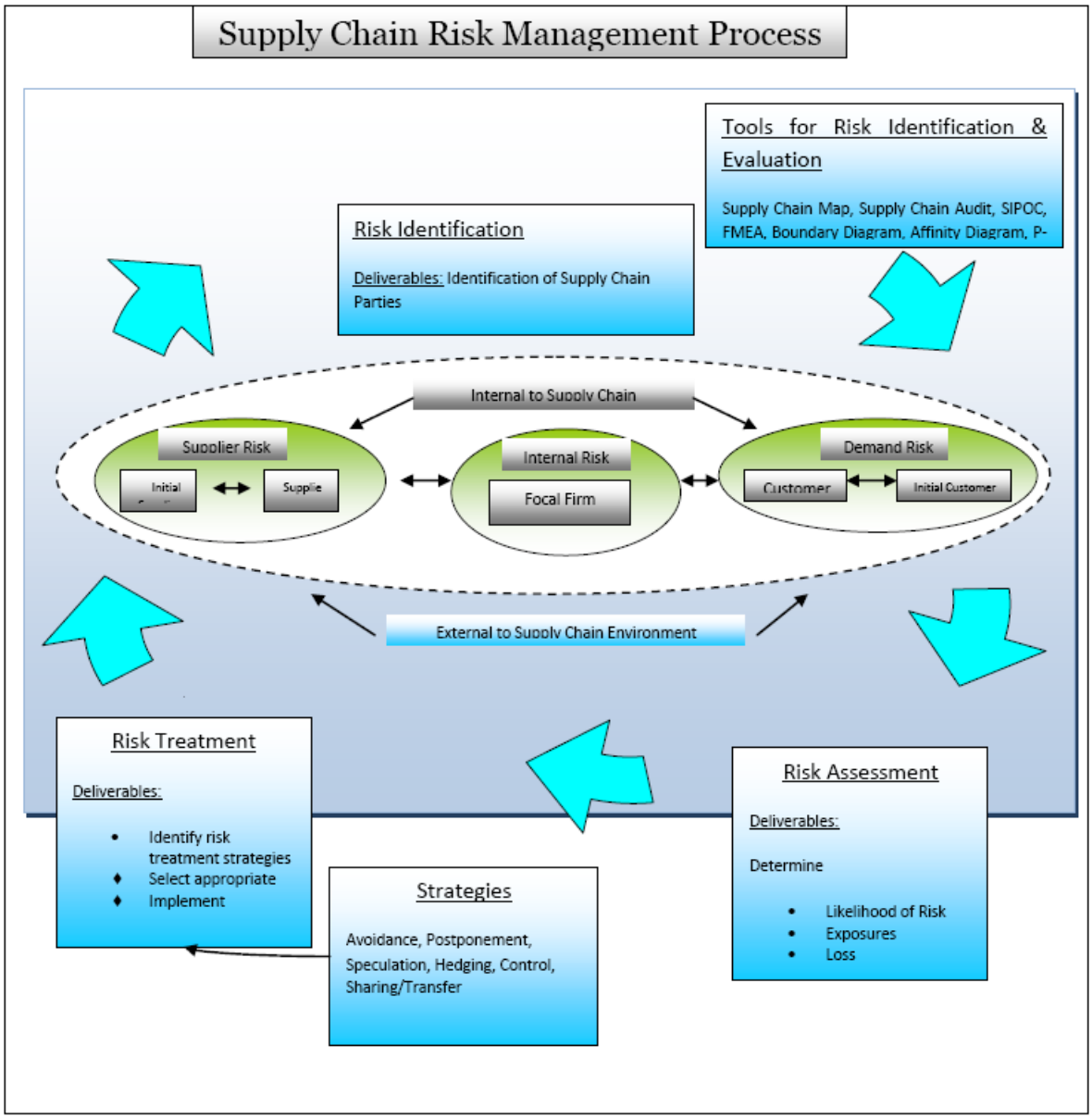


Fig :23 SCRM Framework

5.6 CONCLUSION

In this chapter, we have performed a detail literature review on previously published survey papers, risk management frameworks and articles associated to conceptual type. The chapter is continuation of previous chapters and concludes with supply chain risk management framework. In the framework, we have checked the applicability of ISO 31000 RM framework and validated it's all stages through literature review in order to see which stage or aspect of framework is mostly addressed by authors and used in industry. Clearly, we able to find that three main aspects of framework are mostly used by authors risk identification, evaluation and treatment. In the framework, we try to identify different tools and approaches used by or proposed by academicians and industrialists for each stage. Furthermore, we have enlisted all possible risk management strategies qualitative or quantitative in nature extracted from literature. The framework is developed for a general SCRM problems and issues and it may be applicable to specific SCRM issues with slight modification. Furthermore, managers can have an insight on different types of risks and issues from different industrial sectors and with the knowledge of that; they can plan an effective risks management framework for their firm.

CHAPTER 6

A FRAMEWORK FOR 3PL PROCESS OUTSOURCING

Overview

In this chapter, we provide a general framework for establishing and managing 3PL relationships that consists of four steps: i) identifying and justifying the need for outsourcing logistics activities; ii) 3PL selection; iii) contracting; and iv) relationship management. The aim of this framework is to understand the important elements and issues to consider in each step on order to enhance logistics outsourcing performance. Such knowledge is critical for managers to have in today's competitive business environment.

6.1 INTRODUCTION

In a typical supply chain, companies acquire raw materials, spare parts or components, products or services from suppliers locally or globally to achieve their objectives in turbulent business environment. This process is also known as outsourcing. Similarly, when a company outsources all or some of its logistic functions to third party, the process is known as third party logistics outsourcing (3PL). The worldwide usage of logistics outsourcing has grown dramatically over the last decades and will continue to do so. This trend is also observed in Saudi Arabia where the use of 3PL has been growing with potential for further development. The ability of 3PLs to play an important role in today's global supply chains will depend on their continued ability to provide value to their customers. This value arises from providing logistics services in a more cost effective manner than can be achieved by customers performing the activities themselves.

The appropriate Logistics network of a supply chain is being used to achieve different supply chain objectives such as cost reduction, responsiveness and improvement in profitability. Firms can make three choices when designing their logistics network.

i) Either all logistics functions are performed in house

ii) or firms can own logistics subsidiaries through buying a logistics firm

iii) or firms can outsource the logistics function partially or fully to a third party.

The criticality of 3PLs in the success of any business is clear from a survey based on responses from 1,133 3PL users and non-users, as well as 3PL s, which were added for the first time to the survey group in 2009. According to results, shippers regard logistics and supply chain management as key to their success, and many credit 3PLs with helping them to achieve critical service, cost, and customer satisfaction goals. 65% of shipper respondents report an increase in use of outsourced logistics services; while an average of 24% of shipper respondents are returning to in sourcing some of their logistics activities, and 36% of 3PL respondents observe that some of their customers are in sourcing certain logistics activities (Annual Third party logistics study 2010).

Global 3PL Revenues for 2009

Region	2009 Global 3PL Revenues (US$ billions)
North America	128.1
Europe	162.3
Asia-Pacific	136.7
Latin America	27.6
Other Regions	52.4
Total	507.1

Source: Armstrong & Associates, Inc., 2010

Fig 24: Global 3PL Revenues in 2009 (Annual Third party logistics study 2010)

Fig 25: 3PL Experience (Annual 3PL Study 2010)

In this chapter, we provide a general framework for establishing and managing 3PL relationships that consists of four steps: i) identifying and justifying the need for outsourcing logistics activities; ii) 3PL selection; iii) contracting; and iv) relationship management. The aim of this framework is to understand the important elements and issues to consider in each step on order to enhance logistics outsourcing performance. Such knowledge is critical for managers to have in today's competitive business environment.

To achieve the objective, we identify and discuss various factors that influence logistics decisions. We then establish a framework and discuss various solution methodologies for 3PL outsourcing process. Finally, we discuss various risks involved or associated to each of these influencing factors and proposed risk treatment strategies.

The rest of the chapter is organized as follows. We first present the methodology of research. The scholarly work done in 3PL process outsourcing framework will then be presented stage by stage in order to understand possible aspects of frameworks. Within each step or phase, we try to develop a sub framework for that particular section only. Following this, we present a real case study for empirical verification purpose. Then, based on secondary data approach and case study, we propose a framework for 3PL outsourcing process. Finally with the help of literature review and case study, we able to find risks associated to 3PL process. Risks belong to each phase of our framework are identified and strategies are presented for their mitigation.

6.2 APPROACH AND METHODOLOGY

A comprehensive literature review in 3PL outsourcing process and relationship management was performed to determine all important aspects and elements. The literature search has been performed through various electronic databases including Science Direct, Emerald Full text, ABI/INFORMS Global Pro Quest, ISI web of Knowledge, Scopus and Inderscience. The search was performed by typing various combinations of words such as 3PL, third party logistics, logistics outsourcing, supplier selection and relationship management etc. However, we did not restrict to 3PL only, we have consulted various others articles associated to other outsourcing practices. Articles not belonging to refereed journals such as conference papers, notes, books were discarded. In an attempt to understand what steps and practices are needed in order to successfully establish and manage 3PL relationships, we analyzed various prescriptive models and decision frameworks of 3PL that have been suggested in the literature. A process model for logistics alliance formation, management and control was offered by (Bagchi, P., & Virum, H. 1998) which comprise three phases: identification of the need for the alliance; planning and management; and measurement and control of operations.

Also, (Maltz, A., & Ellram, L. 1997) provided a conceptual model of the 3PL process with five stages: identify the need to outsource logistics; develop feasible alternatives; evaluate and select supplier; implement service; and ongoing service assessment. A major modification of the total cost of ownership framework was proposed by (Sink, H.L., Langley,

C.J., 1997), which they call total cost of relationship (TCR), to deal with logistics outsourcing decisions. Also, (Lambert, D., Emmelhainz, M., & Gardner, J. 1999) presented a model of partnership development and implementation based on three major elements: drivers (e.g. asset/cost efficiencies, enhanced customer service and profit growth/stability), facilitators (e.g. corporate compatibility, similar managerial philosophy, mutuality and symmetry) and management components (e.g. planning, joint operating controls, communications and risk/reward sharing). The purchasing process for advanced versus basic logistics services was also modeled and compared by (Andersson, D., Norrman, A., 2002). They focused on three phases identified as particularly critical in the purchase of advanced logistics services: service definition, request for proposal and contracting.

More recently, (de Boer, L., Gaytan, J., Arroyo, P., 2006) presented a prescriptive model for guiding outsourcing decision processes that incorporates some basic principles of behavioral decision-making theory, in particular the satisficing concept. Furthermore, there are various surveys articles that investigated 3PL related articles from procurement process to termination process. (Razzaque et al 1998) has thoroughly investigated articles related to 3PL by analyzing all important aspects in the process. Key aspects considered were 3PL definition & Evaluation, service consideration and outsourcing, drivers of outsourcing, importance of outsourcing, types of 3PL providers, Advantages and obstacles of outsourcing, and critical factors in logistics outsourcing. (Micheal et al 2006) investigated also research opportunities in 3PL context by considering functions to outsource, reasons to outsource, 3PL evaluation and success factors and barrios. Furthermore, (Konstantinos et al 2007) analyzed articles related to 3PL by classifying them into three broad levels. Firms level , the dyad level or inter organizational level and finally at network level. (Alessandra et al 2008) also reviewed research articles according to unique framework. i.e. Context, Structure and process and outcomes. He classified all articles associated to 3PL into above mentioned framework.

(Andreas et al 2008) proposed a framework for purchasing transport services in small organizations. According to this framework, there are two essential senior management decisions to be made, namely the trade-off between service/cost and transit time/cost. Once the service versus cost priority is established an SOP can be created, KPIs developed, service quantified and a tender document produced. Transport data are important to the tender document, to make the account attractive and to the cost model to calculate the total cost of each bid. The third senior management decision is which 3PL(s) to choose and is based on the cost model and common purchasing aspects like culture fit, reputation, etc. Supplier

development starts once a 3PL moves to the implementation stage. The inputs for supplier development are the KPIs which express the SOP requirements and agreed transit times. The purpose at this stage is to improve service. At certain intervals the company may wish to benchmark the rates offered by the current 3PL by approaching other 3PLs.

(Kwok Hung Lau, J. Z. 2006) proposed a framework for making outsourcing decision in china. In the beginning stage, motivational drivers and obstacles to outsourcing are considered. After making the decision, anticipated outcome and barriers to such outcomes are managed.

These frameworks and review articles help us to determine a structure of a framework to start and classify our search with. Based on these, we were able to determine three main phases of any outsourcing process, Pre-Contracting Phase, Contracting Phase and post contracting phase. Pre contracting phase represents all those activities and function that are performed for making decisions regarding whether to outsource or not, what should be outsource and assessment of needs and organizational capabilities. Contracting phase is the one where agreement is made between both parties for new alliance and finally post contracting phase represents all activities that are performed to survive and manage the relationship till termination. As we go further in to deep, we are able to develop a more general and relatively more matching classification/phases that are also compatible with real world industrial practices as well.

Based on this review, systematic arrangements of all important elements and aspects in 3PL outsourcing process was made and finally we able to derive a conceptual framework based on frequency of citations and frameworks proposed previously.

Furthermore, to assess the applicability of derived framework to industry, a questionnaire was designed consisted of all derived phases of framework. Interviews were taken from leading petroleum firm and their counterpart 3PL service provider. It was analyzed that which of the phases and activities in the proposed framework were used by these firms and what and when logistics factors were considered by the companies during the process. The information collected and the findings of the study help to close the gap between theoretical work and actual practices in organizations.

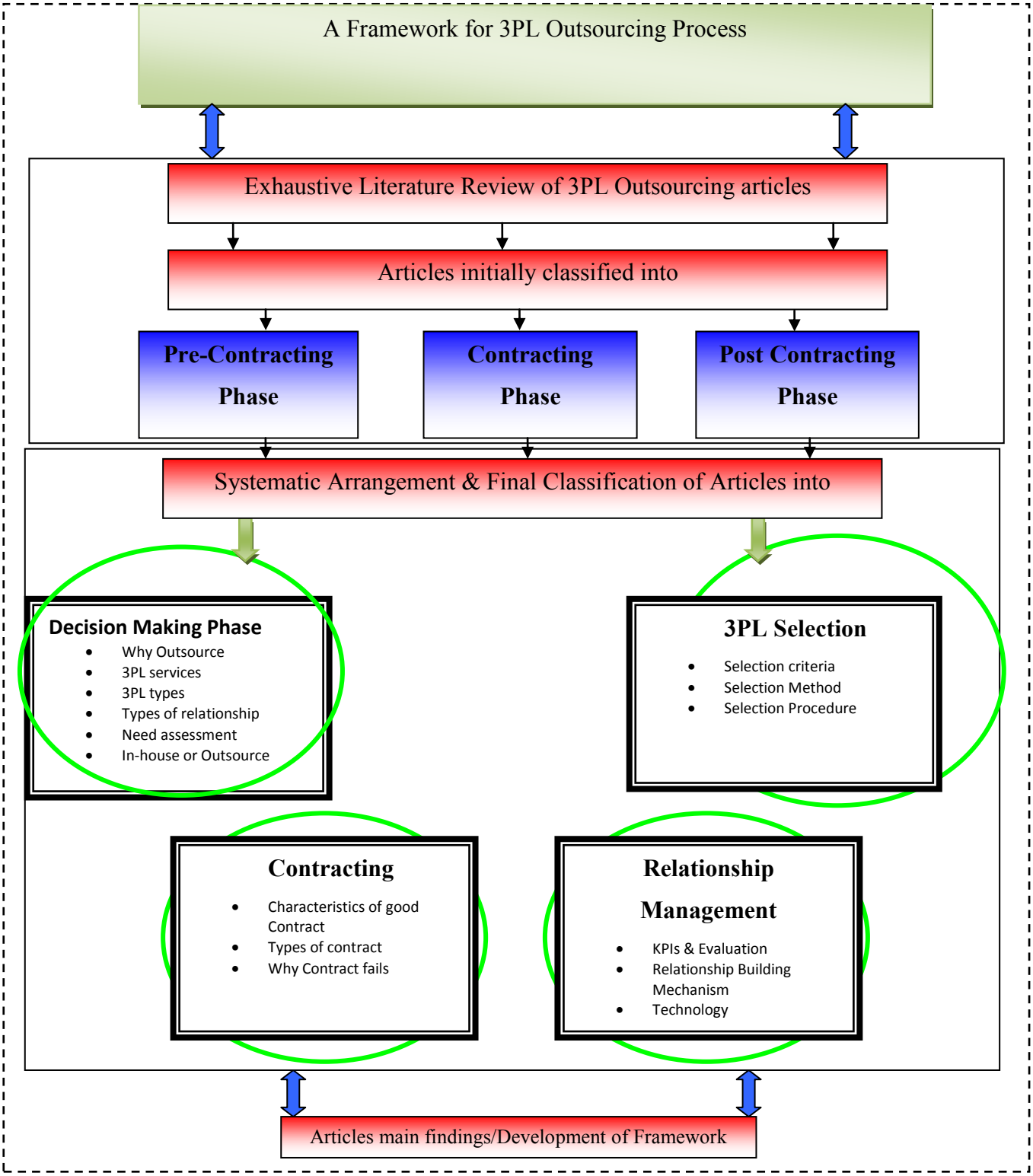


Fig 26: 3PL Process Outsourcing Framework

6.3 DEVELOPMENT OF FRAMEWORK THROUGH LITERATURE

Starting from here, we present step by step derivation of framework. One important aspect need to keep in mind that there is a sea of articles associated to 3PL with full of information related to different sub processes. Presenting all information here is not the scope of this article. However, we tried our best to enlist all possible articles in the tables 1, 2, 3 and 4 for reader's references. In the following section, we have considered key papers to each phases only which help to develop and building framework.

6.3.1 PRE CONTRACTING PHASE

Many authors have analyzed the role of outsourcing strategy in the 3PL alliances. Such as investigation of outsourcing affects to management orientation (e.g. customer or production oriented; vertical or horizontal hierarchy), business relationships (e.g. short or long term; equality regarding risks and rewards), performance measurements (cost, productivity, customer service, asset management, and/or quality). Among these, whether outsourcing increases the importance of logistics, reverse logistics, reengineering, as well as if outsourcing of various supply chain activities affect the relation between local and overseas market share and source of supply. (Per Hilletofth et al 2010) address these types of questions by investigating how a company's strategic vision can be affected or influenced by outsourcing logistics functions. A very recent research made by (Dilay celebi et al 2010) where author presented an analytical model for evaluation of best logistics partnership strategy with the considerations of quantitative and qualitative information with multiple dimensions.

Another aspect is the motivation behind the outsourcing decision. Due to its tremendous effects on a firm and supply chain, a firm must has a clear understanding of expected benefits and advantages that will be attained after outsourcing. (Sheffi 1990) identified various economical, regulatory and technological drivers that motivate organizations for 3PL outsourcing, such as Increased global competition, de regulation of the transportation industry, rising customer expectations on superior logistical service, growing focus of companies on core competencies, increasing popularity of just-in-time (JIT), and revolution

in computers and communication technology. Another important driver is advancement in information technology (IT) for 3PL deployment that motivate firms to go for 3PL outsourcing. (Lewis and Talalayevsky 2000). They observed that effective information processing and communication technology allows both parties to have direct communication and reduce communication cost as well. Furthermore, (Rao and Young 1994) classified factors behind outsourcing into network complexity, process complexity and product complexity. In network complexity, Author referred to both the geographic dispersion of the firm's trading partners as well as the intensiveness of transactions with selected trading partners. In process complexity, author referred to time and task compression (or lack thereof) in the logistics process; and in product complexity, relating to the special circumstances required by products and materials due to the complexity of the environment (temperature, humidity etc.) governing their transportation, storage and handling. Lack of the needed competence and resources within the own company is another major driver that let the company to outsource its logistics (Ericsson et al 2004). Focus on core competencies is another important driver that leads firms to outsource their logistic functions (Razzaque and Sheng 1998) and (Bouson 1999). Various motivational factors are presented in the table 1
(Sink and Langley 1997) mentioned variety of benefits classified as strategy, finance and operations related. Improving customer satisfaction and provision of access to international market are also important advantages. (Bask, 2001).

3PL outsourcing offers many cost-related advantages such as reduction in asset investment (turning fixed cost into variable), labour and equipment maintenance costs (Bardi and Tracey, 1991). Many authors cited cost reduction as primary reason for 3PL outsourcing. Such as (zineldin and bredenlow 2003), (wilding and jurido 2004), service improvement resulting from 3PL provider's focus and efficiency greaver 11 1999 and lynch 2004, potential of helping companies to realize a competitive advantage (Christopher, 1993; Bowersox *et al.*, 1995; Fawcett and Cooper, 1998; Mentzer and Williams, 2001), Medium to develop new products (Zacharia and Mentzer, 2007), to ensure market orientation (Fugate *et al.*, 2008), to achieve superior business performance (Sezen, 2005; Schramm-Klein and Morschett, 2006) and to gain exceptional financial results (Green *et al.*, 2008), increased market coverage (Skjoett-Larsen, 2002), improved customer service (Richardson, 1995), reduction in capital investments (Richardson, 1992; Lacity et al., 1995; Fantasia, 1993), cost savings (Lau and Zhang, 2006; Richardson, 1995), reduction in the complexity of logistics operations (Bradley, 1995), and increased flexibility towards the changing requirements of customers (Lau and

Zhang, 2006). [taken from Per Hilletofth et al 2010], better utilization of capacity and spread of logistic costs due to serving multiple customers (Damme and Ploos van Amstel, 1996).
Forming relationships with 3PL providers is an efficient and effective means of achieving the required service without investing heavily in assets and new capabilities (Persson and Virum, 2001; Stank and Maltz,1996). In this way, shippers can focus on their core business.
Furthermore, changes in the business environment, increased competition, pressure for cost reduction and the resulting need to restructure supply chains are often quoted as motives for the formation of alliances with 3PLs (Bagchi and Virum, 1996; van Laarhoven and Sharman, 1994).Initially 3PL providers were restricted to carriers, transporters and warehouse providers. But as time passes they diversified by offering many services and activities. Many authors provided in detail about the activities performed by 3PL in the literature.
The decision to outsource (or not) logistics activities depends on a various factors. (Rao and Young 1994) have identified such factors and were referred to them as internal and external factors, such as centrality of the logistics function, risk and control, cost/service trade-offs, information technologies and relationships with 3PL. . Furthermore, they identified logistics complexity as another critical driver that has positive impact on above mentioned factors. Product-related (e.g. special handling needs), process-related (e.g. cycle times) and network-related (e.g. countries served) were also found to be significant drivers that have indirect influence in the outsourcing decision (Rao and Young,1994).

Table 19: Key Motivationals Factors/Drivers of Outsourcing

Reference	Key Motivational factors/Drivers of outsourcing
(Kremic et al., 2006). Cited by Jouni Juntunen	Reduction in capital expenditures, the transfer of fixed to variable costs, quality improvement, increased speed, greater flexibility, access to latest technology / infrastructure, access to skills and talent, increase focus on core functions, get rid of problem functions, copy competitors, reduce politic pressures or scrutiny, legal compliance and better accountability/management
Cited by KONSTANTINOS et al 2008	Strategic factors: Focus on core competence, Gaining access to external logistics expertise, Gaining access to new markets, Access to international logistics networks, Improve customer satisfaction, Flexibility in relation to market changes, Financial factors Economies of scale, Reduction in capital investment, Reduction in equipment maintenance costs, Reduction of financial risk, Turning fixed costs to variable, Reducing labour costs Sharing development costs, Providing external benchmark for logistics costs/logistics cost awareness Operational Better capacity utilization, Volume flexibility, Inventory reduction, Order cycle reduction, Lead-time reduction, Access to logistics nformation Systems
YEUNG, A. C. (2006)	Pricing factor Timeliness of service , Quality of delivery, Customised supplementary services
Kwok Hung Lau, J. Z. (2006)	Economic factors: Cost reduction To improve profitability, To improve operating efficiency, To add value to product, Cost saving, To improve cash flow To increase efficiency , Capital investment, reduction , To make capital funds more available for core areas, To improve return on assets, Strategic factors, Acceleration of business process re-engineering, To improve performance , To achieve competitive advantage, Focus on core competence, To improve business focus, To increase competitiveness, To leverage the firm's skills and resources, To enhance customer satisfaction , Flexibility enhancement, To reduce constraints of organization's own productive capacity, To convert fixed costs to variable costs, To increase responsiveness to market change, To reduce risks , Environmental factors, IT development, To meet increasing demand for new information systems and resources more efficiently and economically , Globalization, To help companies gain global competitive advantage Capability of supplier, To enable partnering to improve service quality and customer service and increase competitive advantage

(van Damme and Ploos van Amstel 1996) identified another four categories of considerations related to outsourcing decision ,economic viability, market issues (demand variability and customer service),personnel/equipment availability and extent of supplier dependence. They also identify several favorable conditions for outsourcing such as expanded assortment and demand seasonality. (Hong et al. 2004b) discuss determinants of outsourcing in terms of the shipper firm's characteristics (e.g. firm size). Organizational structures such as decentralized line activities or centralized line activities have significant impact on outsourcing decisions. (Daugherty and Droge 1997). The outsourcing decision is also affected by evaluation of cost/service trade-offs. One important determinant of the decision is cost comparison between alternative options. Costs associated with performing logistics activities in-house and investment in capital assets with service provider fees. The lowest cost solution should then be selected (van Damme and Ploos van Amstel, 1996). According to (Maltz 1994b) organizations were reluctant to use third-party warehousing due to customer service considerations. Several authors have applied TCE theory to the logistics outsourcing decision. For example, (Aertsen 1993) argued that high asset specificity coupled with difficulties in performance measurement should lead to in-house distribution. (Maltz 1994a) found that high asset specificity is associated with in-house warehousing, whereas high transaction frequency leads to outsourcing. (Skjoett-Larsen 2000) combined asset specificity and uncertainty to create a framework for the outsourcing decision: 3PL providers must be used in the case of medium-specific assets or in cases of high asset specificity, but low uncertainty. The decision to outsource logistics can also be driven by resource and capability considerations (Bolumole, 2001). Furthermore, outsourcing decision should be examined in the context of corporate and logistics strategy at specific time periods (Fernie, 1999). (Heinritz *et al* (1991, pp. 161-6) consider factors related to quality, capacity, labor, scheduling and skill to be important in a make-or-buy decision. The firm also needs to determine the benefits of outsourcing according to some criteria, such as, return on assets (Trunick, 1989) and include the risk factor in the sourcing decision (Bradley, 1994c). Other considerations include fit with corporate objectives; strengths and strategy; social, political and environmental concerns; secrecy and market conditions (Leenders and Nollet, 1984). Furthermore, firms must first understand the various types of logistics functions that may be outsourced. The next step involves the evaluation of these functions to choose the specific ones for outsourcing (Dobler *et al.*, 1984, p. 95). Decision-makers need to know how their product and the organization can be affected by outsourcing the logistics function. They need

to gain insight into key issues relating to the acquisition of these services (Sink and Langley, 1997). (Goldsmith 1989) believes that the best way for a firm to begin to assess its current logistics capabilities and needs is by posing a series of questions. Some of the key questions are what our company's most significant logistics considerations are: Competitive position? Bottom-line cost? Inventory control of finished goods? Do we have adequate manpower for these functions? Do we have a knowledgeable logistics staff, enough support, and third-party help? Have we made a current cost-benefit analysis of internal staffing versus outsourcing to accomplish our goals? The answers, or even the process of reviewing these questions, should provide top management with an understanding of the strengths, weaknesses and future needs of its logistics operations. Companies should choose third-party logistics providers by matching up the needs of their companies with the essential competencies of the potential logistics service providers (Buxbaum, 1994).

(Copacino 1994a; 1994b) presents a comprehensive framework to help managers in assessing how their logistics decisions will affect their companies' operations at the strategic, structural, functional, and implementational levels. It addresses customer service issues at the strategic level; channel design and network strategy issues at the structural level; warehouse design and operations, transportation management, and materials management issues at the functional level; information systems, policies and procedures, facilities and equipment, and organization and change management issues at the implementation level. Use of this framework helps companies to decide whether to make or buy logistics services. It should, however, be noted that the factors critical to the design of a logistics structure include an accurate definition of customer service; some inside knowledge on competitors; and flexibility of the structure to incorporate a speedy response to future needs of the existing or new customers (Bingham, 1994). Many authors have analyzed importance of modeling to determine make-or-buy decision and considered it as an integral part of logistics analysis and decision making.

It is essential to take into consideration whether the firm's supply chain objective is to achieve high responsiveness level or reduction in operational cost. More specifically, a thorough evaluation of how the functions that have been selected to be outsourced have been performing in-house is a must. It is crucial to match a third-party's strength to the firm's weaknesses. The firm needs to determine how well these services can be integrated into its operations (Trunick, 1989). Achievement of a high level of customer service demands a match between a firm's logistics requirements and the offerings of the logistics providers.

Another important concern is about Logistic Employees in the company? They could be **Retain** in firm or Taken by 3PLs or Fire. Will your Customer Accept a third Party ? How the benefits will be shared with Customer? How Structure of Supply Chain will get change?

The next important element of a decision making phase would be to identify different types of 3PL exist in the market. (Muller 1993b) proposed two basic types of contract logistics service providers, i.e., operations-based and information-based third party logistics vendors. After that, (Muller 1993a) classified types into asset-based vendors, management-based vendors, Integrated vendors and administration-based vendors. (Africk and Calkins 1994) identified that asset-based and non-asset-based providers are the two main types of third-party logistics service providers along with a third type providing hybrid services. The asset-based providers could either be capacity-dedicated or assets-dedicated. In the capacity-dedicated situations, the provider commits to meeting certain volume and service levels specified by the buyer, but will use its assets to serve multiple customers. In the assets-dedicated situations, the equipment or facilities service only one customer. The buyer makes a trade-off between a lower price for the capacity-dedicated project, and greater assurance of meeting service requirements with assets-dedicated undertakings. Non-asset-based providers generally do not own or lease physical assets but provide human resources and systems to manage the buyer's logistics function. The hybrid services providers are subsidiaries of asset-based contract logistics companies generally specializing in project-based services with some of the physical services offered by the parent company. It should be noted that no one category of the logistics vendors is inherently superior to another. Buyers should have

Table 20: Important factors in Decision Making Phae

Summary of Important Factors in DM process	Reference
internal and external factors, such as centrality of the logistics function, risk and control, cost/service trade-offs, information technologies and relationships with 3PL, logistics complexity Product-related (e.g. special handling needs), process-related (e.g. cycle times) and network-related (e.g. countries served)	Rao and Young (1994)
economic viability, market issues (demand variability and customer service),personnel/equipment availability and extent of supplier dependence	van Damme and Ploos van Amstel (1996).
shipper's organizational structure such as decentralized "line activities" centrally	Daugherty and Droge (1997)
Evaluation of cost/service trade-offs ,cost comparison between alternative options. Costs associated with performing logistics activities in-house and investment in capital assets vs outsource	(van Damme and Ploos van Amstel, 1996)
customer service considerations	Maltz (1994b)
Asset specificity	Aertsen (1993)
high asset specificity is associated with in-house warehousing, whereas high transaction frequency leads to outsourcing.	Maltz (1994a)
Asset specificity	Skjoett-Larsen (2000)
resource and capability considerations	(Bolumole, 2001)
Outsourcing decision should be examined in the context of corporate and logistics strategy at specific time periods	(Fernie, 1999).
Quality, capacity, labor, scheduling and skill to be important in a make-or-buy decision.	Heinritz *et al* (1991, pp. 161-6)
Determine the benefits of outsourcing according to some criteria, such as, return on assets	(Trunick, 1989)
Risk factor in the sourcing decision	(Bradley, 1994c).
fitness with corporate objectives; strengths and strategy; social, political and environmental concerns; secrecy and market conditions	(Leenders and Nollet, 1984).
Understanding and evaluation of various types of logistics functions that may be outsourced.	(Dobler *et al.*, 1984, p. 95)
Understanding of impact of outsourcing on organization and product	(Sink and Langley, 1997)
company's most significant logistics considerations such as Competitive position, Bottom-line cost, Inventory control of finished goods. adequate manpower , knowledgeable logistics staff, enough support, and third-party help, cost-benefit analysis of internal staffing versus outsourcing	Goldsmith (1989)
Understanding of firm's need and comparison with the essential competencies of the potential logistics service providers	(Buxbaum, 1994).
Impact of logistics decisions on companies' operations at the strategic, structural, functional, and implementation levels.	Copacino (1994a; 1994b)
an accurate definition of customer service; some inside knowledge on competitors; and flexibility of the structure to incorporate a speedy response to future needs of the existing or new customers	(Bingham, 1994).
Modeling to determine make-or-buy Strategic Evaluation about firm's supply chain objective such as cost reduction or responsiveness	Trunick, 1989)
concern about Logistic Employees in the company,Retain in firm, or acquire by 3PL or fire	

knowledge about the various providers and make a selection based on their own goals and needs (Muller, 1993b; Sink and Langley, 1997). It has been advocated that instead of focusing on the service providers' assets, firms should consider their skills, and see how those skills compliment what the firms have in-house (Minahan, 1995).

(Razzaque and Sheng, 1998; Sheffi, 1990) also categorized 3PL providers into asset-based and non-asset based. Asset-based providers own physical assets such as truck fleets and warehouses and focus on the management and execution of transport and warehouse-related activities. Non-asset based firms rely on human expertise and information systems and offer management-oriented services, sub-contracting physical distribution activities to asset-based companies. (Berglund et al. 1999) identified asset-based, system (non-asset) based providers , , service based (offering low cost, specific competitive services to many clients) and solution (customized and complex services to a few key customers) providers. (Hertz and Alfredsson 2003) classify 3PLs in terms of their abilities for general problem solving (co-ordination) and the extent of adaptation to client needs. (Persson and Virum 2001) present a typology of 3PL vendors in terms of service complexity and degree of asset specificity. Based on RBV theory, (Lai 2004) has proposed a typology of 3PLs in terms of their service capabilities and performance results.

(Hertz and Alfredsson 2003) cited by (hilletofth et al 2010) provide a useful classification model that distinguishes between four types of 3PL providers: (1) Standard 3PL providers: offer standardized services such as pick and pack, warehousing, and distribution, or even assembly, as argued by (Hilmola et al. 2005). These providers usually have many customers who can choose from different standard services or make uncomplicated combinations of them. This type of actor usually offers no helpwith problem solving besides the standard services. (2) Service developers: offers, in addition to standardized services, more value added services, such as tracking and tracing, cross-docking, specific packaging, or providing a unique security system. (3) Customer adapters: take complete control of the customer's logistics function and processes, at the request of the customer. This implies that they manage, operate, and improve the customer's whole logistics processes; these providers usually improve the logistics dramatically, but do not develop the processes further. The customer base is typically quite small, and they work closely with their customers. (4) Customer developers: in addition to complete control of the customer's logistics function and processes also develop the processes further by developing new and customer adapted services. It is the highest level that a 3PL provider can attain and implies more advanced

services involving high integration with the customers. Various authors have discussed types of relationship that can be made with 3PL providers in order to achieve most of advantages. (Kopczak 1997) investigated the linkages between formation of logistics partnerships and supply chain restructuring in the computer industry. Study findings indicated that the logistics outsourcing via a partnership facilitates supply chain restructuring by allowing greater changes to be made more quickly and with less investment. (Bhatnagar and Viswanathan 2000) illustrated the benefits of a strategic alliance between a manufacturer and a global logistics service provider within the context of contemporary supply chain imperatives of cost efficiency and customer responsiveness. (Panayides and So 2005) found that logistics service provider–client relationships, through the adoption of relational exchange, can improve supply chain effectiveness and performance by promoting a positive climate for learning and innovation. According to (Stone 2001) 3PLs employ a variety of growth strategies. Important means of expansion include mergers and acquisitions (M&As), joint ventures, strategic alliances, piggybacking (i.e. following the client's expansion and establishing new operations in foreign markets) and organic growth. Another important form of relationship is vertical (shipper-3PL) and horizontal (among 3PLs) alliances. Another important classification of relationship is provided by is Transactional Outsourcing Based on transactions, with no long term contracts and no bonding between the 3PL and the outsourcing company. Tactical outsourcing is based on a long term basis with negotiated contacts and integrated IT systems to facilitate free information flow and create supply chain visibility.

Strategic Outsourcing **is** based on long-term relationships with successful outcomes, 3PL companies become partners in supply chain management and establish transactional transparency. [REF]

Another useful classification is Single Transaction, Repeated Transaction, Partnership Agreement, Third Party Agreement, Integrated Logistic Service Agreement.

Table 21: Literature Review on Pre-Contracting Phase

	3PL Decision Making Process						
Paper/Article author	**Why Outsource**	**3PL Services**	**3PL types**	**types of relationship**	**Need Assessment**	**In-house or outsource**	**Risk in 3PL**
Sheffi (1990).	X		X				
Lewis and Talalayevsky (2000),	X						
Bask (2001)	X		X				
Delfmann et al. (2002).	X						
Rao and Young (1994)	X					X	
Daugherty et al 1996							X
Daugherty and Dro ge (1991	X					X	
Daugherty and Dro ge (1997	X					X	
Murphy and Poist (1998)	X	X					
Kopczak (1997)				X			
Bhatnagar and Viswanathan (2000)				X			
, Bhatnagar (1999)	X					X	X
Panayides and So (2005)				X			
(Sink and Langley, 1997	X						
(Ellram and Cooper, 1990							X
Wilding and Juriado, 2004	X						
Damme and Ploos van Amstel, 1996	X					X	X
Bardi and Tracey, 1991	X					X	X
Ackerman, 1996							X
Wilding and Juriado, 2004		X					X
van Laarhoven et al., 2000	X						
Lieb and Bentz, 2005a		X					
Lieb and Kendrick, 2003		X					
Lieb and Randall, 1999		X					
van Hoek, 2001	X					X	
van Hoek, 2000b		X				X	X
van Hoek and Dierdonck, 2000		X					
Sink et al.,1996			X				
Razzaque and Sheng, 1998			X				
Berglund et al. (1999			X				
Hertz and Alfredsson (2003)			X				
Persson and Virum (2001)			X			X	
Stone, et al 2001				X			
Stone, 2002				X			
Carbone and Stone, 2005				X			
van Hoek 2000				X			
Evans, 2000				X			
Hong et al. (2004b						X	X
Londe and Maltz, 1992						X	
McGinnis et al., 1995						X	
Sarel and Zinn, 1992						X	
Maltz (1994b						X	
Aertsen (1993						X	
Bolumole, 2001						X	
Stank and Maltz,1996						X	
van Laarhoven and Sharman, 1994						X	
Fernie, 1999	X					X	
Boyson et al., 1999	X					X	X
Capgemini et al 2003	X						X
Capgemini et al 2004	X						X
Dapiran et al 1996	X						X
Gutierrez and Duran et al 1999	X					X	
Knemeyer et al., 2003							X
celebi 2010				X			
Hsiao et al (2010)		X					
gourdin et al 2006	X						

6.3.1.1 Main findings and summary of Pre-Contracting Phase

From above discussion and thorough literature review, various aspects have been distinguished within the pre contracting phase.

- Development of outsourcing strategy according to supply chain objectives,
- Clear understanding of types of 3PLs available in the market,
- Understanding of nature of relationship with 3PLs,
- Understanding of needs and what to outsource, Understanding of resources and capabilities

6.3.1.2 Framework for Decision making phase

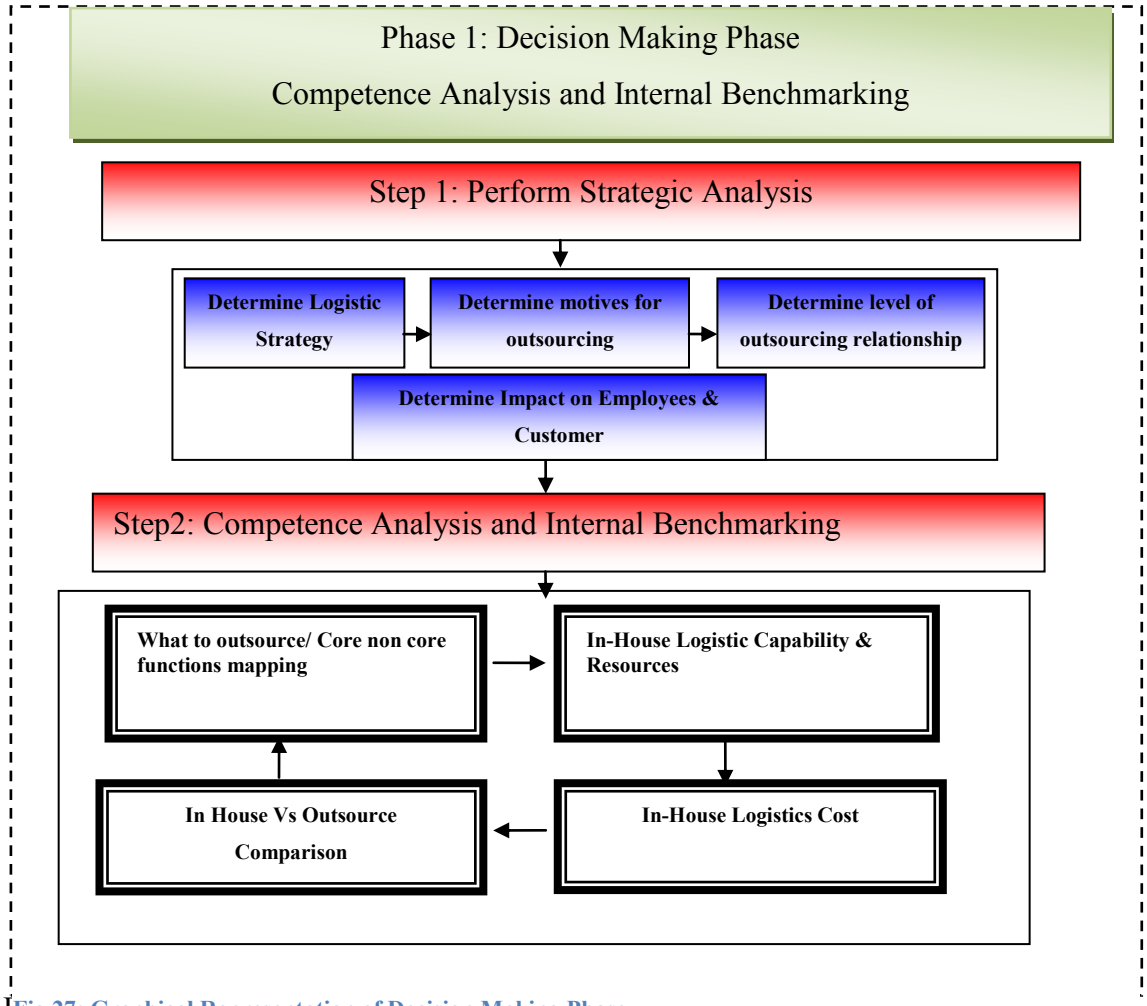


Fig 27: Graphical Representation of Decision Making Phase

6.3.2 3PL PROCESS PHASE 2- 3PL SELECTION

Once the decision has been made to work with a 3PL, the next step is to determine which provider to choose. Thus, the selection of an efficient and potential set of 3PL that can meet the particular requirements of the customer and with whom the customer can strengthen its relationships becomes a crucial decision. (Bhatnagar et al., 1999) cited by (Soh et al 2010). This decision is influenced by several factors such as price, services offered, location, technology, quality, etc. In the coming section, we try to identify several important characteristics considered useful in selection criteria. Before, talking further about selection criteria, one must understand the significance importance of proper selection criteria. There are two dimensions along which proper selection criteria help firm's i.e. help the firm to pick 3PL most suited to their needs and involvement of all stakeholders in the selection criteria which will eventually leads to most reasonable 3PL. (Maltz 1995).

Furthermore, (Soh et al 2010) cited that to evaluate all possible supplier candidates and select the most suitable supplier, a set of criteria must be defined. By establishing a set of selection criteria, a company will be better able to select a 3PL provider that will best fit its needs and existing operations.

It is not difficult to find or know about 3PL providers in a market or region. However, companies are being used various approaches for knowing 3PL providers, Such as through Professional logistics networks, Management magazines and journals, 3PL providers ads (in all media), Recommendations from business partners, Referrals from consulting firms and Recommendations of internal personnel. (Sohail et al 2005).

After knowing about the proper sources of information about 3PL network, company need to determine about the proper selection criteria that suits their requirements. The literature is full of such articles where generic and specific selection criteria have been analyzed. Listing them all is not the scope of this article. However, we have enlisted most of these articles in table. Here we discussed most general and important criteria that can be considered as minimal requirements. An important aspect needs to be considered here is the order of importance of criteria. The order of importance of the criterion depends on several factors such as the demand level of the firm, its activity, the relation type which it projects to create with the 3PL etc. (Aicha et al 2007). The order of importance of the criterion depends on several factors such as the demand level of the firm, its activity, the relation type which it projects to create with the 3PL, etc.

Now we try to identify the most cited and least cited selection criteria in the literature in order to indentify and derive a general criteria list under which all other elements proposed in the literature would fall in.

The two most frequently cited reasons for outsourcing logistics activities are cost savings and service improvement expectations through outsourcing. (Cited by Soh et al 2010).

Factors such as cost, service quality and reliability, flexibility, responsiveness to requests and financial stability are often-cited criteria for the selection of 3PLs. Some criteria are developed with specific client needs in mind, while others are common for all circumstances (Bagchi and Virum, 1996). Many authors regard to the relative importance of the price factor; some authors (e.g. van Laarhoven and Sharman, 1994) rank it as top criterion, while others argue that service performance and quality requirements precede discussions about rates (Menon et al, 1998). Qualitative factors such as supplier reputation, references from clients and response to information requests are used for the initial screening of candidate service providers (Sink and Langley, 1997). Cost is not the single most important decision variable; logistics service issues are also considered (Selviaridis and Spring, 2007). Thus, 3PL users need to balance cost with service (Setthakaset and Basnet, 2005). (Roberts 1994) proposed the level of service provided, the quality of people, and cost as the three most used evaluation criteria in the choice of a qualified logistics provider. This is also reflected in the work of (Bhatnagar et al. 1999), (Dapiran et al. 1996) and (Lieb et al. 1993); they found that cost and service represent the most important criteria in logistics outsourcing decisions. (Boyson et al. 1999) found that financial stability, customer service capability, and service price were rated as the most important characteristic for selecting 3PL providers. In addition to cost and service, a variety of other selection criteria have been cited in literature. According to a survey of 154 firms offering warehousing services in the United States by (Spencer et al. 1994), the most important evaluative criteria for selecting external or third-party service providers are, in descending order of importance, the following: on-time performance, service quality, communication, reliability, service speed, and flexibility. (Menon et al. 1998) reported that logistics managers consider perceived performance and perceived capability as important factors in selecting 3PL providers and that these variables tend to increase in importance when the external environment is competitive. Perceived performance is comprised of perceived on-time shipments and deliveries, the ability to meet promises, the availability of top management, and superior error rates. Perceived capability is

comprised of perceived creative management and the financial stability of the provider. While 3PL reports an increasing interest in environmental issues, buying decisions are still

Table 22: Key Selection criteria cited in Literature

Reference	Key Selection criteria proposed and cited by academicians
M.N. Qureshi et al 2008	Quality of service, Size and quality of fixed assets, The quality of management, Information technology capability, Delivery performance, Information sharing and trust, Operational performance Compatibility , Financial stability, Geographical spread and range of services, The long-term relationship, Reputation Optimum cost Surge capacity Flexibility in operation and delivery
Soh, S. (2010)	**Finance:** Logistics costs, Financial stability, **Service** level, Reliability and timeliness Quality of service, Flexibility and responsiveness **Relationship :** Compatibility, Trust and fairness, Benefit and risk sharing **Management:** Performance management, Security and safety, Reputation and experience **Infrastructure:** IT/IS capability, Logistics manpower
International Warehouse Logistics Associa-tion,	price, reliability, service quality, on-time performance, cost reduction, flexibility and innovation, good communication, management quality, location, customize service, speed of service, order cycle time, easy to work with, customer support, vendor reputation, technical competence, special expertise, systems capabilities, variety of available Services, decreased labor problems, personal relationships, decreased asset commitment, and early notification of disruptions.
Huang and Kadar (2002)	industry/operation experience, reputation, lower price, network coverage, own strategic asset, integrated logistics pro-viding capability, and good IT system
Moberg and Speh (2004)	Responsiveness to service requirements, quality of management, track record of ethical importance, ability to provide value-added services, low cost, specific channel expertise, knowledge of market, personal relationship with key contacts, willingness to assume risk, investment in state-of art technologies, size of firm, and national market Coverage.
Roberts (1994)	level of service, quality of people, cost
Boyson et al. (1999	financial stability, customer service capability, and service price
Bienstock et al. (1997) Cited by Jouni Juntunen et al 2010	Timeliness , availability condition
Mentzer et al. (1999; 2001)	personnel contact quality, order release quantities, information quality, ordering procedures, order accuracy , order condition , order quality, order discrepancy handling timeliness
Stank et al. (2003)	operational performance, relational performance, cost performance
Grant (2004a)	order service and quality, relationship service, relationship quality
Rafaele (2004)	tangible components (assets, personnel, inventory/availability), ways of fulfillment (flexibility, service care, supply conditions, lead time), information actions (marketing, order managing, after sales, e-business)
Davis and Mentzer (2006)	Reliability, communication, timeliness, responsiveness
Jayanth et al 2010	Commitment to quality, Reserve capacity or the ability to respond to unexpected demand Industry knowledge , Financial stability and staying power Scope of resources , Ability to meet delivery due dates
Hao-Tien Liu et al 2009	Price, Financial considerations, Experience in the similar industry, Location, Asset, ownership, International scope, Growth forecasts, Market share, Logistics equipment Optimization capabilities, Logistics information system, EDI capacity, Customer service On-time shipments and deliveries, Capability to handle specific business requirements Responsiveness, Service quality , Continuous improvement , Value-added services KPI (key performance indicator) measurement and reporting, Accessibility of contact persons in urgency, Cultural fit, General reputation, Service cancellation, Human resource policies Availability of qualified talent
Cited by	capability/technical competence, _ capacity/flexibility, client references/provider

KONSTANTINOS et al 2008	reputation, communications, compatible IS/IT, creative management, expertise/specialist knowledge, financial stability/strength, service quality, price/cost, knowledgeable sales-force, harmonised planning horizons, geographical coverage/networks, network customisation, experience in handling specific product types, sub-contracting practices, supply of critical information, responsiveness/ability to meet promises, reliability/on-time shipment and delivery, personnel quality/human resource management, performance measurement, top management availability, experience in specific industry familiar with industry regulations
Tug˘ba Efendigil,et al 2008	On time delivery ratio (ROD), Confirmed fill rate (CFR) , Service quality level (SQL) Unit operation cost (UOP) , Capacity usage ratio (CUR), Total order cycle time (TOCT) System flexibility index (SFI) , Integration level index (ILI), E-commerce integration technologies , Increment in market share (MSI), • Research and development ratio (RD) , Environmental expenditures (CEN)
Baofeng Huo et al 2008	Reliability of delivery Speed of delivery, Quality of service , Customer service , Flexibility of service , Variety of services offered , Speed of introduction of new services Relative price position , Relative cost position
Hakan Go¨l , B. l. C. a. (2007)	General company considerations, Price Competitive pricing that will be derived from the quotations, Financial considerations Liquidity, operating, profitability, and leverage ratios are the selected ratios for measuring the financial situation of the 3PL providers Experience in the same industry , The geographic area served by the provider ,The distribution of the offices/ branches/warehouses of the service provider, Asset ownership International scope , Growth forecasts , growth capability, Yearly efficiency, Optimization capabilities , Information tech. systems, Customer service , SC vision (Capacity to accommodate and grow the client's business) , Creative management (Flexibility and capability to handle specific business requirements) , Responsiveness (to Unforeseen Problems or Unexpected Events),Service quality , Continuous improvement Reputation Key performance indicator (KPI) measurement and reporting, Client relationship Availability of top management, Cultural fit Capability with company culture and policies , General reputation , Labor relations, Human resource policies , Availability of qualified talent
Cited by Gülfem I,sıklara et al 2007	financial stability, successful track record, similar size, comparable culture, similar values and goals, and fit to develop a sustainable relationship. information technology, performance, quality, cost and services
Cited by Aicha et al 2007	Price, Reliability, Service quality, On-time performance , Cost reduction , Flexibility and innovation , Good communication , Management quality , Location , Customise service, Speed of service, Order cycle time, Easy to work with , Customer support , Vendor reputation, Technical competence , Special expertise , Systems capabilities , Variety of available services, Decreased labour problems, Personal relationships , Decreased asset commitment, Early notification of disruptions, Increased competition , Global capabilities
Spencer et al. (1994),	on-time performance, service quality, communication, reliability, service speed, and flexibility
Menon et al. (1998)	perceived performance and perceived capability
Aghazadeh (2003)	similar value/objectives, up-to-date information technology systems, trustworthy key management, and a relationship of mutual respect and shared willingness
McGinnis et al. [17]	on time shipment and deliveries, superior error rates, financial stability, creative management, ability to deliver as promised, availability of top management, responsiveness to unforeseen occurrences, and importance of meeting performance requirements before price discussions occur

Fig28 : 3PL selection criteria

made on “traditional” performance objectives, such as price, quality and timely delivery. Environmental concerns have not been incorporated (christina wolf et al 2010).

6.3.2.1 3PL Selection Methods:

In this section, we try to review approaches and methods that have been used for the selection and evaluation of 3PL service providers. These selection methods can be classified as qualitative and quantitative methods or hybrid as well. (Aicha et al 2007) classified quantitative models into 4 main categories. Decision making tools based on linear weighting models such as AHP and ANP. These models place a weight on each criterion and provide a total score for each 3PL by summing up the 3PL performance on the criteria multiplied by their associated weights. They are easy to use and can be implemented inexpensively. However, they totally depend upon human judgment.

Another important classification is methods based on statistical approaches such as standard deviation or mean etc. Such methods are tough to analyze and usually do not go for optimal solution. The third category that has been used a lot methods based on mathematical programming. Usually we can enter constraints into them but optimality is not even guaranteed. Another classification is based on Systems dynamic tools such as artificial intelligence etc. They offer a flexible base of knowledge consider many qualitative factors during analysis. In the following table we have classified various approaches and tools according to above mentioned classification.

Furthermore, we tried to summarize those articles as well that have presented complete framework for supplier selection.

(M.N. Qureshi et al 2008) has presented a complete framework for supplier selection process. In the framework, main phases are data collection for the service required, define service and distribution objective, develop distribution functional specification, identify potential third party service providers, developing criteria and objective for RFP, integrated model to identify and classify key criteria, Evaluate of RFP response and beginning of new partnerships. Furthermore, (Dey et al 2010) presented a five steps model to choose an effective 3PLs provider and Including following steps: making decision, developing criteria and objectives, the weeding out process, determining the top project and beginning the new partnership. (Sanjay et al 2007) proposed a selection procedure as follows. Develop a team of competitive managers, Define service and distribution objectives, develop distribution and

functional specification, identify potential providers, development and evaluation of RFP, Evaluate RFP, Field visit s and inspection, final selection and agreement

Type/Classification		Tools/Approach	References
Qualitative Approaches		Qualitative Internal Evaluation	
		Recommendations based on Consultants	
Quantitative Approaches	Linear Weighting	AHP	So et al. [2006] Go¨l and C¸atay (2007) Soh, S. (2010) Hakan Go¨l , B. l. C. a. (2007)
		ANP	Jharkharia and Shankar [2007], Meade and Sarkis [2002] Dilay Çelebi et a l 201 Sanjay et al 2005
	Artificial Intelligence	expert systems	Ying and Dayong [2005]
		case-based reasoning (CBR).	Yan et al. [2003] Is¸ıklar et al. (2007).
	Statistical analysis	binary logit model	Tsai et al. [2007]
		linear programming model	Chen et al. [2001]
		multi-objective programming model	Kumar et al. [2007]
		Data Envelopment Analysis (DEA)	Rogers [2007] Min and Joo (2006) Zhou et al. (2008)
	Hybrid/Integrated approach	hybrid intelligent decision support framework CBR, RBR (rule-based reasoning) and compromise programming techniques	Isiklar et al. [2007]
		integrating interpretive structural model (ISM) and ANP	Thakkar et al. [2005]
		artificial neural networks and fuzzy logic	Efendigil
		, fuzzy inference, and fuzzy linear assignment techniques	Liu and Wang (2009)
		TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) technique and the fuzzy set theory	Bottani and Rizzi (2006)
		fuzzy AHP and fuzzy TOPSIS approaches	Bu¨yu¨ko¨zkan et al. (2008)
		Integrated Fuzzy approach	Hao-Tien Liu et al 2009
		two-phase model based on artificial neural networks and fuzzy logic	Tug˘ba Efendigil et al 2008

A five steps model was presented by (Aghazadeh, S.M et al 2003) involved in selecting an effective 3PL and which are: making decision on the need to use or not a 3PL, developing criteria and objectives which the provider should meet, weeding out process by making a list of possible 3PL, determining the top prospect to meet the potential 3PL, and beginning the new partnership with the chosen provider.

(Hao-Tien Liu Et al 2009) also cited steps for supplier selection . The first task in provider selection is to form a team of analysts who have a rich knowledge and expertise in logistics activities. The team members should include different experts from the organization such as sales, marketing, manufacturing, finance, and logistics (Jharkharia & Shankar,2007).

Next, the evaluation team should determine all possible evaluation criteria prior to provider selection. The evaluation criteria used for the provider selection problems have been widely discussed in many researches

6.3.2.2 Framework for 3PL Selection

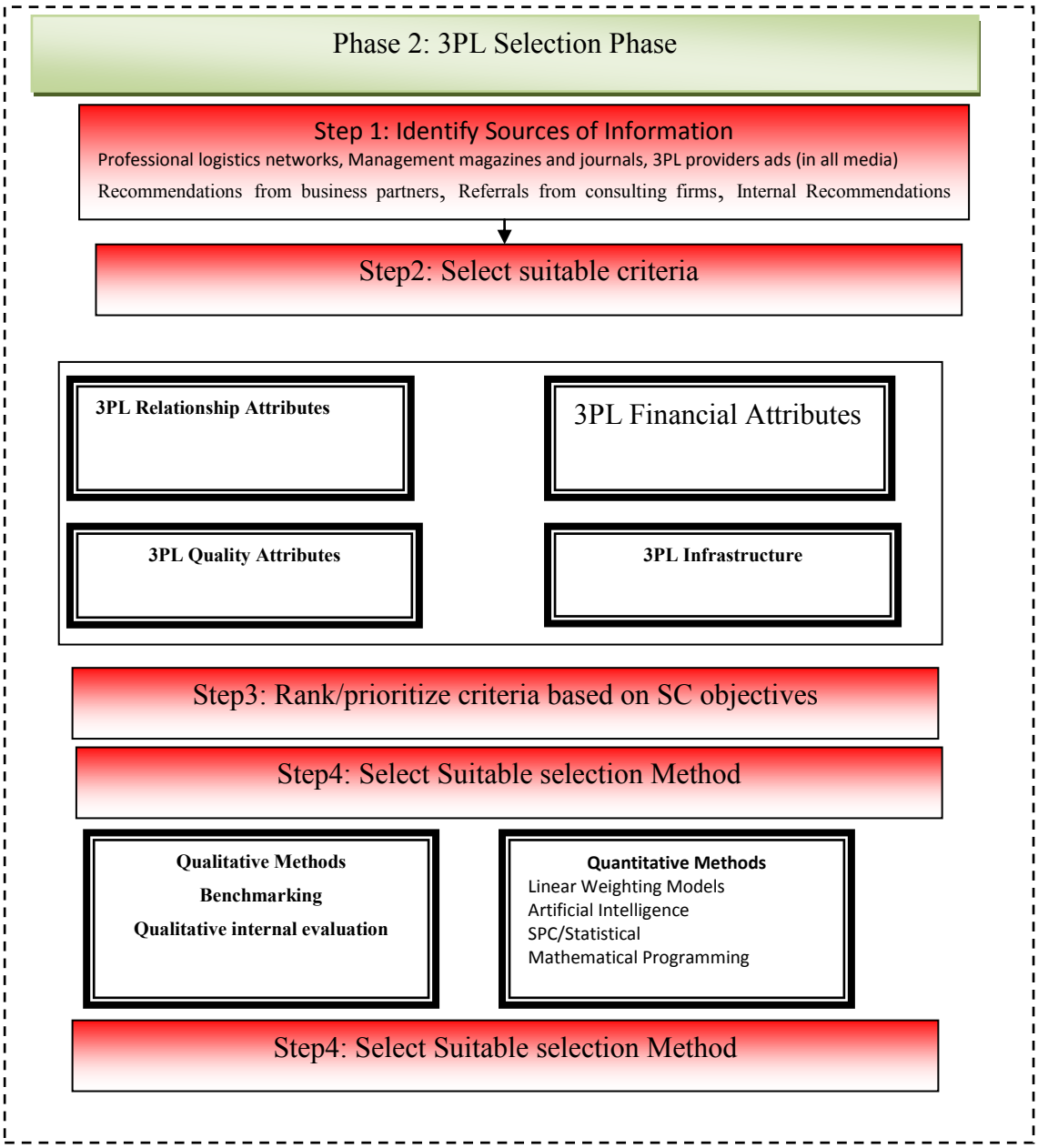


Fig 29: A framework for 3PL Selection

Table 23: Literature on 3PL Selection

3PL Selection					
Paper/Article author	Sources of Information	3PL attributes	Selection criteria	Selection Procedure	Selection Method
McGinnis et al. (1995)			X		
Menon et al. (1998),			X		
Meade and Sarkis (2002)			X		
Vaidyanathan (2005)			X		
Bottani and Rizzi (2006)			X		X
Colson and Dorigo 2004			X		
Moberg and Speh 2004			X		
So et al. 2006					X
Jharkharia and Shankar 2007					X
Meade and Sarkis 2002			X		X
Ying and Dayong 2005					X
Yan et al 2003					X
Tsai et al 2007					X
Chen et al.2001					X
Hamdan and Rogers 2007					X
Isiklar et al. 2007					X
Thakkar et al. 2005					X
Tugba et al 2007					X
Bagchi and Virum, 1996			X		
van Laarhoven and Sharman, 1994			X		
Crum and Allen, 1997			X		
La Londe and Maltz, 1992			X		
Menon et al., 1998			X		
Sink and Langley, 1997			X		

Aghazadeh, 2003			X	X	
Sink et al., 1996			X		
van Damme and Ploos van Amstel, 1996			X		
forrest et al 2008-			X		
Vijayvargiya et al 2010		X	X	X	
Soh et al 2010			X		
liu et al 2009			X		
jayanth et al 2010			X		
Dilay Çelebi et a l 2010					X
Dev et al 2010				X	
M.N. Qureshi et al 2008				X	
Christina et al 2010			X		
Hao-Tien Liu et al 2009			X		X
KONSTANTINOS et al 2008			X		
Tug˘ba Efendigil et al 2008			X		X
Gulcin Buyukozkan et al 2008					X
Sanjay et al 2005			X	X	X
Hakan Go¨l , B. l. C. a. (2007)			X		
Gülfem I¸sıklara et al 2007			X		X
Aicha et al 2007			X		X
YEUNG, A. C. (2006)			X		
Lieb, D. R. (2004).					

6.3.3 PHASE 3: 3PL CONTRACTING

After determination of appropriate 3PL service provider, contract is written between both parties. When firms and suppliers across a supply chain get together, they tend to have such contracts that not only maximize their profits but allow them to make decisions independently with minimizing risks also. Furthermore, Contracts should be designed to facilitate not only the supply chain objectives but to create win - win situation for both parties. An important aspect in contracting is the consideration of contract's impact on both parties profit and supply chain profit. Furthermore, one must think about the incentives in the contract whether they lead to any information distortion. (Chopra et al). According to (Barthelemy et al 2003),a good contract helps establish a balance of power between the client and the vendor. It also allows partners to set expectations and to commit themselves to short-term goals and it provides a safety net in case the relationship fails. (Osei-Bryson et al 2006) emphasizes that managers must understand that how outsourcing contracts be structured to ensure reliability and quality.

Contracts are an important part of the analysis of outsourcing decisions. They can provide effective mechanisms for managing the outsourcing relationship and early termination provisions in cases of underperformance.

Many scholars analyzed various types of contracts and their pros and cons as well. There would be many types of contracts available in the outsourcing literature such as Letter of Intents or Umbrella Agreement, Short Contract, Detailed specification Contract, Open book Contracts, Closed book contracts, Outcome based Contracts, Behavior based Contracts, Fixed Fee Contracts, Incentive Contract, Revenue sharing contract, Quantity flexible contract, Two part tariffs and threshold Contract, Shared Saving contract etc.

(Osei-Bryson et al 2006) discussed two classes of outsourcing contracts, fixed fee and incentive. In a simple fixed fee contract the payment to the vendor is fixed but the vendor can negotiate additional payments for variations. Under the fixed fee contract (FFC) the vendor is responsible for all the risk of cost overruns, but if he can improve efficiency he can make a higher profit.. Another type of fixed fee arrangement is the cost plus contract (CPC), which involves the risk of cost overruns that would be borne solely by the client. The second type, incentive contracts, attempts to share the risks and rewards between the client and the vendor. Generally, they specify an expected level of service and penalties for under-performance and

incentives for various levels of performance. Penalties and incentives are important features of any type of outsourcing contract;

There are two main types of incentive contracts; fixed price incentive contracts (FPIC) and variable price incentive contracts (VPIC). Both types of contracts carry an incentive and a penalty provision. But they differ in how they manage the risks of vendor under-performance. A FPIC is used when both the outsourcer and the vendor know the cost of information processing. The outsourcer agrees to pay the vendor a portion of the agreed upon price in advance of the performance of the activity. A post-performance audit is carried out. If it is found that the vendor under-performs a penalty is charged to the vendor. If the vendor performs to the specified level he is paid the balance on the contract. The outsourcer can also offer additional incentive payments for higher levels of performance.

Another class of contracts are Outcome based and behavior based contracts. In a buyer-supplier relationship, outcome-based contracts would typically involve some type of price premium (Klein and Leffler, 1981) in order to "make cheating unprofitable" (Mishra et al., 1998, p. 280). Thus, outcome-based contracts could involve cost-plus incentives and/or risk/gain sharing. Behavior-based contracts would "stipulate specific behaviors required" by the buyer and "may impose restrictions on variables such as inventory levels, range of products stocked [. . .]" (Lassar and Kerr, 1996, p. 616).

The challenge associated with outcome-based contracts is that "outcomes are only partly a function of behaviors" that are under the agent's control and, as such, outcome-based contracts place more risk on the agent (Eisenhardt, 1989, p. 61). There are various challenges associated to both contracts. A challenge associated with outcome-based contracts is that such contracts require a method for monitoring the performance outcomes. The cost of using outcome-based contracts increases when performance outcomes are difficult to measure,

In order to reduce/eliminate the ability to cheat, the principal can utilize behavior-based mechanisms to try to ensure the agent behaves in a manner consistent with the principal's best interest. Behavior-based contracts are also not without challenges. The challenge associated with behavior-based contracts is that the agent's behavior has to be monitored. This may require the principal to invest in information monitoring capabilities to reduce

The contractual tradeoffs need to be evaluated by comparing the cost of monitoring the agent's behavior and the cost of measuring the agent's performance outcomes and the cost of transferring risk to the agent. Two key dimensions must be considered while making decision about contract mechanisms outcome measurability and outcome uncertainty. Outcome-based

contracts are efficient when the ability to measure performance outcomes is relatively straight forward and cost effective; When outcomes are difficult or costly to measure, behavior-based contracts are more appropriate The second condition is outcome uncertainty. Outcome uncertainty describes the degree to which the agent can effectively control its performance outcomes. Outcome-based contracts are efficient when the agent has a high degree of influence over performance outcomes; when the agent has less control over performance outcomes, behavior-based contracts are more efficient. In some circumstances when the above two conditions are together appear in situation, joint or mix of two contracts can also be used-

According to one survey more than half of the contracts used in third party logistics relationships in Europe have detailed specifications and specific performance targets are also part of the contracts (Van Laarhoven et al., 2000). According to the same study 40% of the contracts contain penalty clauses if the providers do not achieve the agreed performance targets.

As to the problem contract design, (Logan 2000) illustrated how the logic of agency theory can help to design the types of contracts and relationships necessary to provide and support an environment of trust and mutual satisfaction. (Lim 2000) developed a game-theoretic model of how a contract may be established in order that 3PL providers are encouraged to reveal their true capabilities. (Chen et al 2001) provided a framework for analyzing three forms of third-party warehousing contracts with space commitments and adjustment options. (Alpet al. 2003) devised an approach for designing contract parameters based on the interactions of three defined sub-problems: vehicle dispatching problem, inventory control and contract value problem. According to the literature, (Andersson and Norman, 2002; Boyson et al., 1999; Logan, 2000) a typical 3PL contract includes:

- contract term (i.e. number of years);
- costs per activity;
- service and activities description;
- service levels;
- bonus payment for excellent performance;
- penalty clauses for service failures;
- Allocation of roles and responsibilities, risks and insurance costs; and contract termination clause.

There would be many different contract wordings as per the business types, environments and legal issue. However, the following table clearly illustrates the general types of clauses need to be included.

Besides these legal issues and business requirements, management make sure that a contract must possess following characteristics.

Preciseness: A contract must be precise. An Ill-defined contract often results in high costs and poor service levels.

Completeness: the more complete the contract the smaller the risk of potential opportunism of the vendor and the more complete the contract, the smaller the probability that it will involve costly renegotiations.

Incentive based: The contract should be written to encourage the right behavior from the vendor. The vendor may get a bonus when its performance boosts indicators of business value. This incentive could help align the goals of vendors with the business objectives of their clients. The contract should also address how the relationship will change over its life cycle. Unit-based pricing may be used at the beginning of the relationship. The pricing could switch to cost-plus as the relationship develops.

Balanced: In general, one-sided contracts do not last long. Even a contract that is weighted against the vendor is not necessarily beneficial for the client: service levels quickly drop, and the vendor tries to win back some value by imposing extra fees.

Flexible: Due to evolving technology and changing business conditions, medium and long-term outsourcing contracts should not be written in an inflexible way. Flexibility clauses can help both parties accommodate to environmental changes.

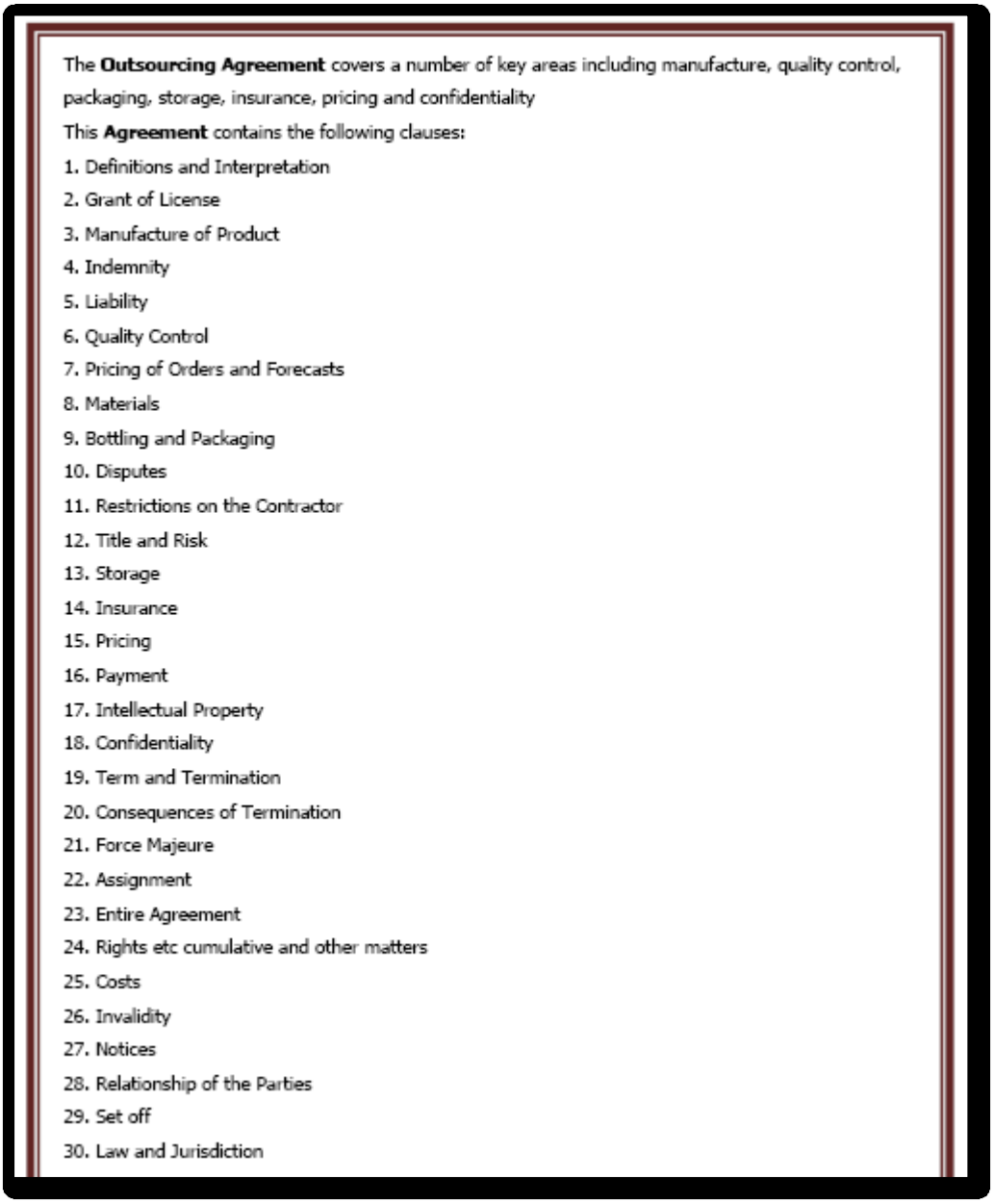


Fig30 : General Clauses of agreement

6.3.3.1 A framework for Contracting Management

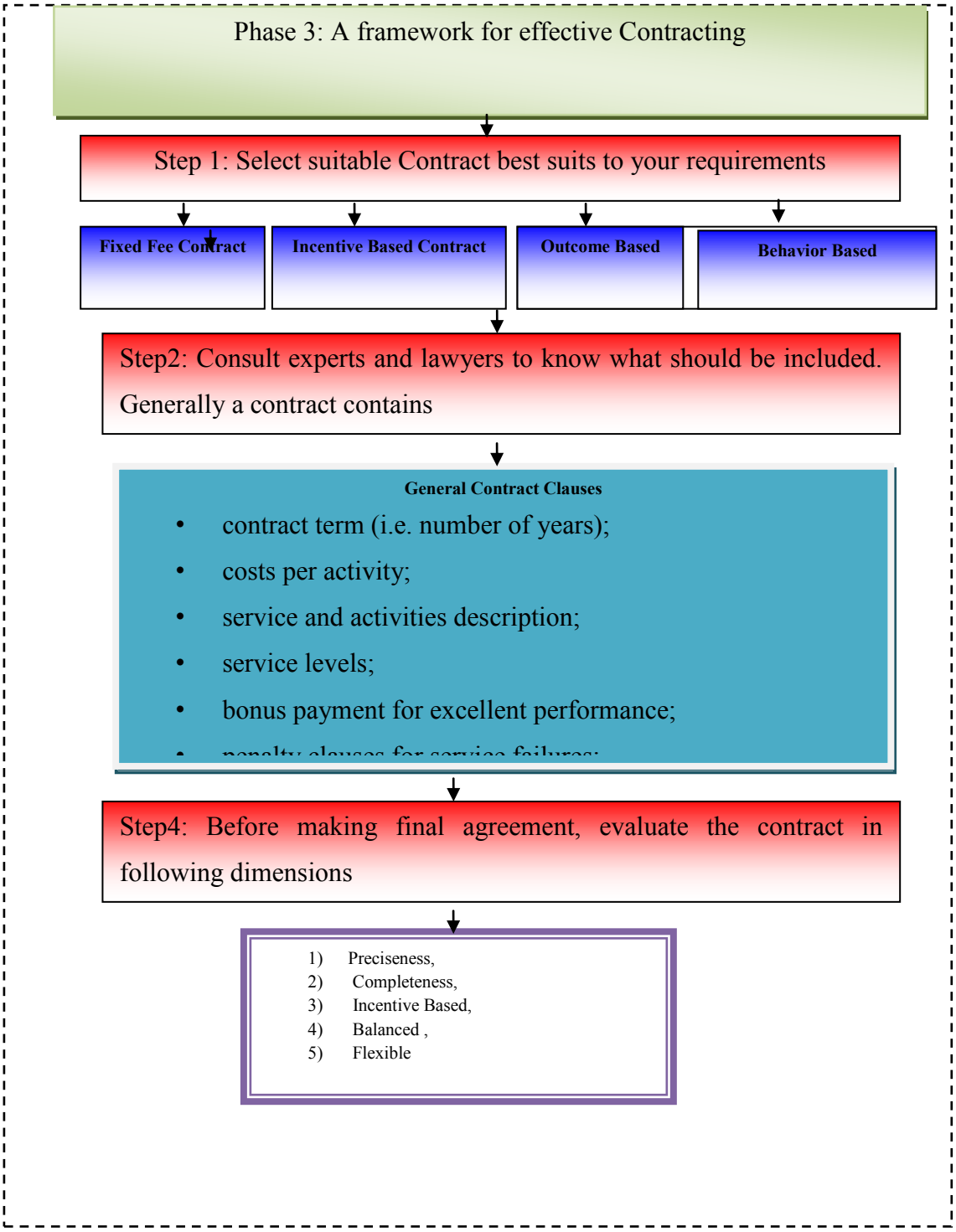


Fig 31: A framework for Contracting Management

Table 24: Liertaure on Contracting Management

Contracting			
Paper	Characteristics	Types	Reasons for failure
Logan (2000)	X	X	
Lim (2000)		X	
Chen et al.(2001)		X	
Alp et al. (2003)		X	
Boyson et al., 1999	X		
Lambert et al., 1999	X		
Andersson and Norman, 2002	X		
, Bhatnagar (1999)	X		
Capgemini et al 2003	X		
Capgemini et al 2004	X		
Fernie, 1999	X		
van Hoek, 2000	X		
Hsiao et al (2010)		X	
Selviaridis et al 2010		X	
Mettew et al 2010		X	
whipple et al 2010		X	
Kostas	X		
Marlow et al 2008	X		
Yikuan Lee, S. T. C. (2006)	X		
Chandrashekar, S. A. a. A. (2000)	X		

6.3.4 PHASE 4: RELATIONSHIP MANAGEMENT

Relationship management comes after contracting phase when both parties start doing logistic functions jointly according to the agreement. This phase includes all post contracting issues starting from transferring responsibilities to contract termination. The objective of this phase is to develop understanding of inter organizational dynamics that lead to successful and long lasting relationships between both parties. Successful relationships are also considered as an antecedent not only to both firm's profit but for supply chain as well. We try to find answers for following research questions.

1) What are the main influencing factors of a successful outsourcing relationship management and how a firm can develop such as mechanism that helps both parties to achieve their partnership objectives?
2) What are the most important strategic relational attributes that would be necessary for a successful relationship?
3) What would be the best KPIs or performance measurements that would not only determine the ongoing performance of 3PL providers but also predict future relationship continuation by measuring relational attributes?
4) Finally the impact of information technology on relationship and possible outcome will be analyzed with the help of thorough literature review.

The very first issue a firm faces with is the transition process when transferring its logistics responsibilities to 3PL Provider. An extensive study of critical trends and issues in 3PL among key markets and key customers in North America and Western Europe found, amongst other things, that users reported unsatisfactory experiences of transition during the implementation stage, which may have been explained partly by an apparent lack of strategic management skills (Langley et al., 2001). In order to have an orderly and planned transfer to service provider, transition planning is vital and significantly important. While making transition planning, two important aspects need to be considered, keep track of customers as the responsibility transfer and focus on the people involved in the process. Transition phase usually have three important elements to consider transition planning, organizational planning and transition of services. The element of transition planning consists of setting up a transition team, auditing resources to be transferred, establishing plan of transition, communicating plan internally and with customers. The organizational planning elements consist of launching new organization, educating staff, setting up review. Finally, transition

of services involves transferring of service, people and assets, watching thoroughly the new services offered to customers and Re-aligning the management processes. Andreas et al 2006

6.3.4.1 KPIs and Performance Evaluation

In this phase we talk about how to develop effective performance monitoring system. i.e what are the different attributes we need to consider while designing evaluation mechanism. There are various articles that have analyzed significance and importance of effective evaluation system. According to (Garland et al 1999), performance is multi dimensions No one measure is sufficed for Logistic performance. Set of measures which collectively capture most are needed in order to evaluate effectively. According to (Beamon et al 1999), indicators need to be capable of evaluating all pertinent aspects, allowing comparison under different operation conditions, evaluating measurable information, and being consistent with the company's goals. (Mentzer et al 1994), cited by (Griffis et al., 2004) suggest that measures should be realistic, representative, consistent, cost effective, understandable, and not ''underdetermined''. They should also be obtained by standard processes, traceable and inexpensive procedures. In addition to that, (Dornier et al. 1998) states that the indicators should be organized by priority and segmented in order to improve their efficiency. According to (Bowersox et al 1996), The main goal of performance measurement is to monitor, control and direct logistics operations. Performance measurement is, a way of allocating and monitoring resources. Measurements should be process-oriented rather than functional-oriented; in order to evaluate the actual effectiveness as it is perceived by the customer. They can be divided into internal and external measurements. The internal measurements are those measurements that can be compared to define goals, and are usually divided into five categories: cost, customer service, productivity, asset management and quality. The external are used to understand and to maintain the focus on the customer, and could be divided into measurements of customer perception and benchmarking of best practices. [Refernces]

According to (Dornier et al. 1998), Performance measurements have the purpose of ensuring that logistics services are in accordance with pre-established goals. Primary management functions are divided into planning and control; the planning phase is based on strategies and forecasts, while the control is the evaluation of the differences between planned and actual results. The key to a successful functional integration is therefore, proper performance measurement, reflecting changes and evaluating their impacts. Any system of performance

measurement should include at least one indicator of efficiency, which is translated into measurement of resources; one indicator of customer service, which is achieved through product availability; and one indicator of adaptability to changes, which can be described by measurement of flexibility.

(Elten Briggs et al 2010) argue about different aspects in performance of 3PL. When services are delivered on an ongoing basis, customers are able to not only evaluate positional (current) performance, but also velocity (rate at which the service changes) performance. Author presented findings from an empirical study utilizing an online survey of 3PL customers to examine the influence of these two types of performance on 3PL service satisfaction. Environmental moderators including market turbulence and competitive intensity are also examined, and results indicate that velocity performance is a more important driver of satisfaction when customers operate in industries characterized by high market turbulence. The findings suggest that 3PL service providers should implement velocity performance metrics, especially for customers operating in rapidly changing environments, and use velocity performance information during the sales process and customer negotiations.

(jayanth et al 2010)

(Beamon et al 1999) has stated that quantitative measurements are usually effective, but in certain scenarios they can be as vague as qualitative ones.

(Hamdan et al 2008) proposed a model based on DEA for evaluating the 3PL efficiency in warehousing . As an input he proposed labor hour, warehouse space , technology investment and material handling equipment. The ouput is shipping volume, order fillingand space utilization.

(Andreas et al 2008) mentioned various KPIs with the SOP introduced as a baseline it was possible to create key performance indicators (KPI) to measure performance to agreed standards. The KPIs are reviewed monthly allowing the LSP to identify challenges and focus efforts in resolving them.

The KPIs have proved useful in improving communication between the 3PL and internal stakeholders; the overall effect on performance has been positive and has created a constructive atmosphere of collaboration between both parties. krakovics et al 2008- proposed various KPIs for effective performance such as operational efficiency (Shipment program accomplishment (SPA)and Packing consumption efficiency (PCE),Internal storage inventory accuracy (ISIA), External storage inventory accuracy (ESIA), internal operation product damage, Finished product packing sweeping (FPPS) Finished product internal

storage sweeping (FPISS), Finished product external storage sweeping (FPESS): External operation product damage, Transportation damage (TD), Transportation accidents (TA): Cargo theft (CT), distribution efficiency, Out-of-date-deliveries (ODD), External client complaints cost (ECC), External client satisfaction (ECS),distribution costs, moving and storage costs, Internal storage moving and storing cost (ISMSC), External storage moving and storing cost (ESMSC),information quality for planning, Shipment estimate precision (SEP) , demand variability, Shipment tonnage coefficient of variation (STCV), Same day programmed shipments (SDPS),

(Gibson et al 2002) further proposed strategies that best represents relational attributes.

Planning, Open discussion of demand forecasts, Joint development of service schedules and goals, Participating in each other's strategic planning, Control/power, Equal power in the relationship, Mutual authority to end the partnership, The authority to require process changes by partner , Flexibility, Proactive management of special needs and exceptions, The ability to handle changing carrier requirements, Trust, A culture of cooperation and trust, Adversarial views are replaced by cooperation and loyalty, Expectation of a long-term relationship, Information sharing, Timely sharing of cost and performance data, The existence of an open book policy, Information sharing at multiple levels across firms

Rules of engagement, A written, detailed contract, A conflict resolution process, A formal process to analyze performance, Simple process to renew, amend, or end contract,

Shared risk and reward, Specific rewards for outstanding performance, Specific penalties for unacceptable performance, An equal distribution of planned and unexpected costs, The willingness to share cost savings (gain sharing), Channel perspective, A clear vision of the supply chain and one's role in it , A focus on supply chain performance improvement, Cost focus , The ability to take cost out of the operation, The ability to control costs, An emphasis on supply chain cost reduction, Performance management, Standardized reports and, reporting methods, The use of quality charts/tools to monitor performance, Well-defined performance metrics , Periodic performance review meetings, Time horizon, A focus on future activities, A long range planning horizon, The ability to weather short-term ups and downs , Strategic fit, Compatible strategies, goals and objectives, Similar management styles Compatible corporate cultures

6.3.4.2 Relationship Building Mechanism

Various variables, used by researchers and practiced by the shippers for effective management of logistics outsourcing relationship have been identified. These variables have

been classified as enablers and outcome variable. Enablers are those variables that boost the "relationship bond" between 3PL service provider and customer, while outcome variables are the resultant variables arising out of outsourcing relationship between both parties.

In this section we have derived the most significant and important enablers that are an essential part of relationship management. We try to understand the answers of three main questions for each enablers. I .e what are the antecedents of each enablers, how to measure and assess its current usage in process and how to build and effective mechanism for each enablers.

6.3.4.2.1 Trust/Commitment

Commitment (or trust) is very critical for customers as well as 3PL as it provides the sound ground for healthy relationship for success (Bradley, 1994; Sheehan, 1989). (Sinclair et al. 1996) described three types of trust: competence, contractual and goodwill, whereas (Hacker et al. 1999) described trust as capability, commitment, and consistency. (Handfield and Bechtel 2004), grouped the trust in to eight conceptual paradigms. The eight paradigms identified were: (1) reliability; (2) competence; (3) goodwill (openness and benevolence); (4) vulnerability; (5) loyalty; (6) multiple forms of trust; (7) combining trust with vulnerability; and (8) The future of trust (non-partisan proactive-based trust).

(Mayer et al. 1995) define trust as the willingness of a party (trustor) to be vulnerable to the actions of another party (trustee) based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party. Trust between 3PL providers and logistics users has proven a key factor in the success of logistics outsourcing relationships (LaLonde and Cooper, 1989; Minahan, 1997; Moore, 1998). High-trust levels in logistics outsourcing relationships reduce transaction and agency costs (Beccerra and Gupta, 1999; Dyer and Chu, 2000). Trust also improves creativity and inter organizational learning (Arnulf et al., 2005), and builds organizational capabilities (Corsten and Kumar, 2005). (Johnston et al. 2004) found that high-trust levels were associated with increases in cooperative behavior among logistics outsourcing partners, which in turn led to higher partnership performance levels. Finally, (Dyer and Chu 2000) suggest that unlike other forms of governance mechanisms (contracts, financial hostages, etc.), trust has the unique capacity to create value beyond transaction cost reductions and can therefore be a source of substantial competitive advantage for logistics outsourcing partnerships. Conversely, lack of trust has been cited as the single most significant obstacle to the successful formation and maintenance of supply chain strategic alliances, accounting for

fully one-third of failures in such relationships (Sherman and Sookdeo, 1992). The lack of trust among relationship partners often results in decreased productivity, efficiency and effectiveness, as partners spend an inordinate amount of time scrutinizing transactions and analyzing each other's credibility, reliability and trustworthiness (Kwon and Suh, 2004). (Bowersox 1990) argues that a logistics outsourcing relationship should have a high degree of trust between partners and that failure to build trust early in the relationship may negatively affect its ultimate success.

Based on a comprehensive review of the trust literature, Academicians and Practitioners uncovered five distinct processes by which trust can develop in business relationships. reputation, information sharing, relationship length, satisfaction, and relationship-specific investment. A 3PL provider's reputation may work as a filter that influences the perception of the operation and behaviors of the 3PL provider. Reputation can serve as the mechanism for transferring trust of the trustee from one trustor to another. Relationship-specific investment is also a critical determinant of the logistics user's trust towards 3PL provider. The specific investment may serve as a strong signal of "good faith" of 3PL providers, because the investment cannot be deployed elsewhere Firms making such investments are less likely to engage in opportunistic and untrustworthy behaviors that could threaten the relationship Thus, the larger the amount one side of a partnership invests in relationship-specific assets, the higher the degree to which that partner is locked into the relationship .The 3PL providers can enhance the trust of logistics users by being open and effective communicators. Sharing information serves as a signal of the honesty and openness of 3PL providers, improves 3PL providers' decision transparency, and reduces relationship risk. To build up the logistics user's trust, 3PL providers should improve customer service to enhance satisfaction levels-Trust can be directly developed through consistent and predictable behaviors of the partner over an extended period. Of all the suggested consequences of trust found in the literature, none is more important to the logistics outsourcing relationship than commitment and loyalty behavior. Logistics users' trust towards 3PL providers has a significant and positive influence on logistics users' commitment to the outsourcing relationship. Logistics users' trust towards 3PL providers has a significant and positive influence on logistics users' loyalty behaviors towards 3PL providers.

6.3.4.2.2 Coordination/Collaboration/Communication

Collaboration is defined as two or more companies sharing the responsibility of exchanging common planning, management, execution, and performance measurement information

(Anthony, 2000). The general idea is that much can be gained from collaborating with supply chain partners. Collaboration has been referred to as the driving force behind effective supply chain management (Ellram and Cooper, 1990; Horvath, 2001) and, as such, may be considered the ultimate core capability (Sanders and Premus, 2005) within a supply chain context. The fundamental rationale behind collaboration is that a single company cannot Successfully compete by it. Customers are more demanding; competition is escalating (Kotler, 1997). Firms enter into inter firm collaborative arrangements in order to share risks and rewards. (Min et al 2008) proposed a theoretical framework for effective supply chain collaboration where the author discussed various antecedents, aspects to collaborate and finally consequences of effective collaboration. The author has provided following antecedent's strategic intent, internal alignments, relationship orientation, investments, free flow of information/heightened communication, and formalization. Please refer to the paper for detail information. Author furthermore describe different elements of collaboration process that needs to be done such as information sharing, joint planning , joint problem solving, joint performance measurement and leveraging resource and skills. Finally the variables for consequences were efficiency, effectiveness, profitability and reinforcement and expansion of the relationship. (Andersson, D., Norrman, A., 200) furthermore provide various aspects in collaboration. According to authors there are some factors that create an uncertain environment that motivates the need for effective collaboration. These factors are the diversity of outputs (products, services, markets) for example number of different customer segments with different service requirements, the amount of different (specialized) input resources with strong inter-dependencies, the rate of unanticipated change the rate of unanticipated change is related to high customer requirements e.g. with respect to short delivery times and handling of exceptional orders, the level of goal difficulty the level of goal difficulty is also related to high customer requirements. According to author, Coordination is usually performed at three different levels. All three types of coordination is necessary for 3PL Partners. Informal coordination. i.e spontaneous communication between the employees of both organizations . For the coordination of daily operations informal coordination is the most effective. Examples are co-location of workers, joint training and other social events, consistent reward and measurement systems, Formal inter-organizational teams consisting of employees from different levels of both organizations may be created for problem solving and improvement purposes. An example would be monitoring customer feedback, predicting future demands and assessment of potential improvements, Integrating roles are needed to

establish inter-organizational teams and coordinate their work so that collaboration between the two organizations is achieved without the need to refer to the top of the hierarchies.
Based on (min et al 2008) analysis, we can derive following sub processes for effective collaboration between 3PL providers and customers.

6.3.4.2.3 Information Sharing

In their empirical study, (*jayanth et al 2010)* analyzed various elements that are considered important for collaboration such as Use of informal information sharing with suppliers and customers ,Use of formal information sharing agreements with suppliers and customers Improving the integration of activities across your supply chain ,Communicating your firm's future strategic needs to your suppliers ,Communicating customers' future strategic needs throughout the entire supply chain ,Creating a compatible information system with your suppliers and customers. According to the survey respondents, shared information is an essential ingredient of day-to-day operations as well as more strategic collaborative activities. Information covering a wide range of activities is shared among various partners. Shared information provides a common base for partners and triggers the flows of products, services, funds, and feedback between the partners. Information sharing is frequent and exchanges become a matter of routine that encompasses multiple levels across the firms. How is information shared? Many survey participants mentioned automated information exchange via information technology such as electronic data interchange (EDI), database (e.g. Wal-Mart's shared database called RetailLink), data warehouse and data mining techniques, and the internet to illustrate their communication channels. A distributor emphasized that shared information provides supply chain visibility that can trigger immediate, corrective actions relating to the flows of raw materials, finished goods, and services as needed.

6.3.4.2.4 Joint Planning

The next component of collaboration, joint planning, is closely related to and dependent upon information sharing. Information drives collaboration that starts with joint business planning between collaborative partners. Joint planning is required to co-align operations as well as capacities of each collaborative partner.

6.3.4.2.5 Conflict Resolution Mechanism/Joint Problem solving mechanism

Joint problem solving is frequently accomplished through the formation of cross-functional teams or by co-locating each other's personnel. One example included development of an

"Alliance Team" consisting of people from each organization representing various functional areas. The Alliance team meets regularly to solve issues ranging from quality control to distribution operations. Joint problem solving often results in breaking down boundaries between collaborative partners. Forming cross-functional, cross-organizational teams and co-locating may evolve into a virtual integration of the supply chain process. In order to resolve conflicts, maintain an open and encouraging atmosphere, so that conflicts are neither intentionally avoided nor resolved through using force by one side. Smoothing down of conflicts is ineffective, because it eliminates the search of all the possible alternatives, and may leave conflicts hidden in the people's minds and thus undermine the quality of the relationship. The best results are achieved by using open problem solving and a confrontation approach in conflict resolution. For this purpose investment in training the team members in problem solving and inter-personal skills should provide high returns. Effective team leadership is important in resolving conflicts, especially when a consensus solution is not reached collectively.

6.3.4.2.6 Organizational culture

Organizational culture plays a relevant role in the development as well as in the maintenance over the time of 3PL arrangements— especially of the close, partnership-like ones—as highlighted, The effects of possible cultural differences due to representation of two different organizations can be mitigated by using clear working approaches. E.g. formal problem solving methods and group decision support systems may be used to facilitate the equal participation of different members. Especially in the early stages of the outsourcing relationship formal working methods may offer a way to improve trust between the partners. It is important for the effective functioning of the team that the members of the two different organizations get to know each other. This can be achieved by using teams of rather small sizes and having frequent meetings.

6.3.4.3 3PL Outcomes

(Mohan, B. S. S. a. R. 2006) has cited various expected outcome if relationship go successful. Such as Impact on customer satisfaction (Gooley 1992); and (Lieb et al. 1993), Impact on logistics system performance (Lieb et al. 1993) and (Dapiran et al. 1996) and (Bhatnagar et al. 1999) Reduction in capital investment in facilities (Foster and Muller 1990) and (Richardson 1992, 1995) Reduction in capital investment in equipment (Fantasia 1993), (Foster and Muller 1990) and (Richardson 1992) Reduction in investment in information

Technology (Goldberg 1990), (Sheffi 1990), (Trunick 1990) and (Fantasia 1993)

Impact on employee morale (Bowersox 1990) and (Dapiran et al. 1996) Reduction in manpower cost (Foster and Muller 1990) and (Richardson 1992, 1995) Improvement on specific logistics function parameters (Minaham 1997) and (McMullan 1996) Improvement in inventory turnover rates (Richardson 1990, 1995) Improvement in on-time delivery (Richardson 1995) Increasing productivity (Bradley 1995)

(M.N. Qureshi et al 2007) has cited various outcomes such as Customer satisfaction Dedicated resources Customer service levels Logistics cost saving Expanded outsourcing Enhanced value

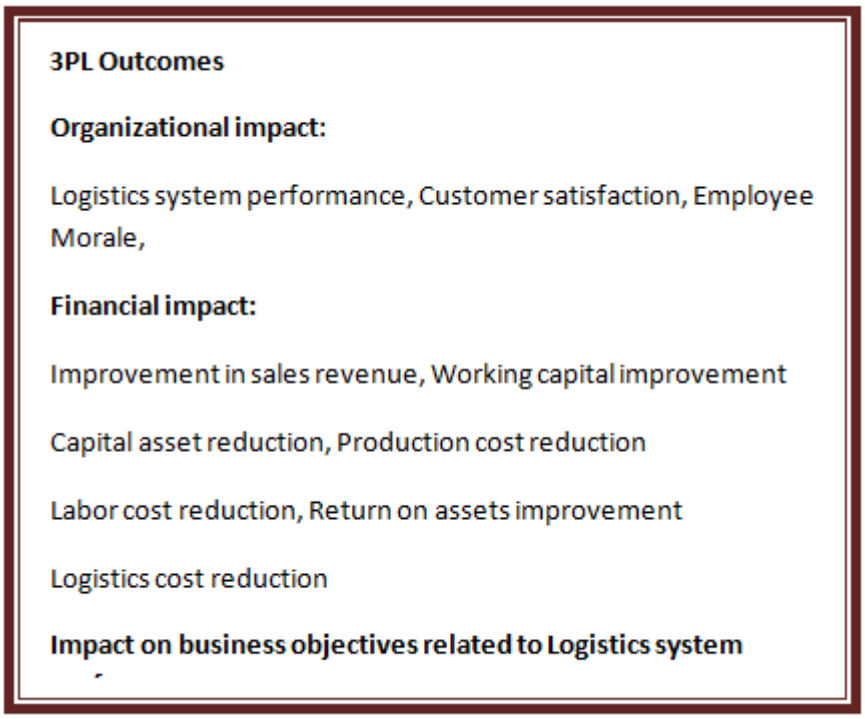


Fig 32: 3PL outcomes

6.3.4.4 A framework for Relationship Management

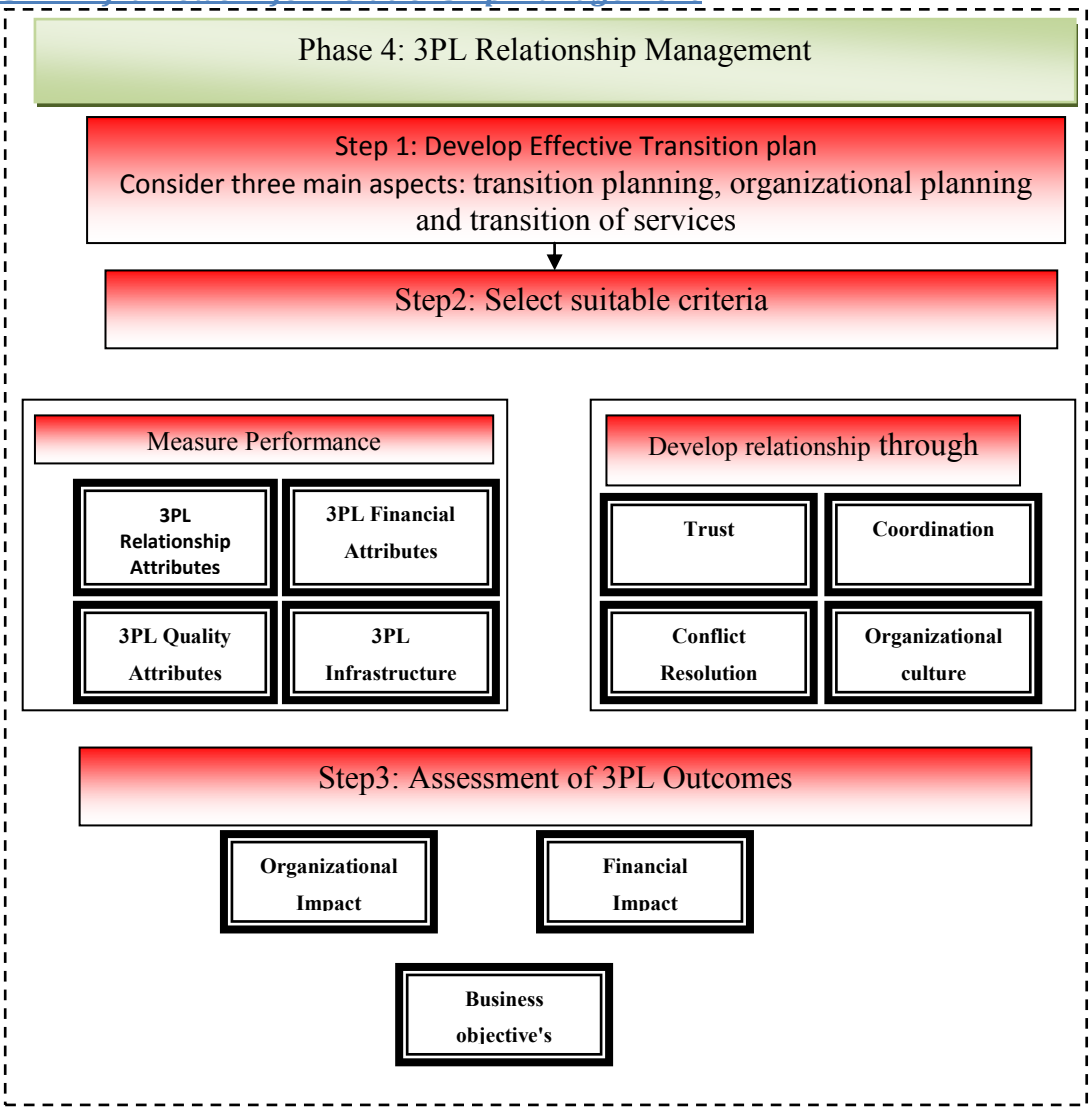


Fig 33: Framework for Relationship Management

Table 25: Literature on Relationship Management

Relationship Management							
Paper	KPIs	Evaluation	Relationship failure	Relationship development	Technology	Framework	Outcome
Gardner et al., 1994				X		X	
Knemeyer et al., 2003				X			X
Knemeyer and Murphy, 2005a				X			
Knemeyer and Murphy, 2005b				X			
Moore, 1998				X			
Moore and Cunningham, 1999				X			
Gentry (1996)				X			
Langley et al., 2002					X		
Langley et al., 2005					X		
Piplani et al. (2004					X		
Lai et al. (2005)					X		
Evangelista and Sweeney (2006)					X		
Koh and Tan (2005)					X		
Ying and Dayong (2005)					X		
Bagchi and Virum (1996)						X	
Sink and Langley (1997)						X	
Maltz and Ellram (1997)						X	
Lambert et al. (1999)						X	
Andersson and Norrman (2002)						X	
de Boer et al. (2006)						X	
(Tate, 1996)				X			X
Bowersox, 1990							X

Daugherty et al., 1996							X
Ellram and Cooper, 1990			X				X
Larson and Gammelgaard, 2001b							X
Aghazadeh et al 2003						X	
van Hoek, 2000							X
van Hoek, 2001	X						X
Wilding and Juriado, 2004	X		X				
Stank et al., 1994	X						
Sum and Teo, 1999	X						
Bourlakis and Bourlakis (2005	X						
Ackerman, 1996			X				
(Stank et al., 1996				X			
Bienstock, 2002				X			
Huiskonnen and Pirttila, 2002				X			
Lambert et al., 1999				X			
Leahy et al., 1995				X			
van Laarhoven et al., 2000				X			
Murphy and Poist, 2000				X			
, Bhatnagar (1999)		X					X
Boyson et al., 1999		X					X
Capgemini et al 2003		X					X
Capgemini et al 2004		X					X
Dapiran et al 1996							X
Daugherty et al 1996							X
Fernie, 1999							X

Gutierrez and Duran et al 1999							X
Hang et al 2004							X
Yu-tian et al 2010	X						
briggs et al 2010	X						
wang et al 2010	X						
forrest et al 2008-							X
Selviaridis et al 2010		X					
jayanth et al 2010	X						
gotzammani et al 2010				X			
liu et al 2009		X					
whipple et al 2010							X
Hilletofth et al 2010					X		
elten briggs et al 2010		X					
Yu Tian et al 2008				X			
Hamdan et al 2008		X					
Gengui et al 2008		X					
Changsu e tal 2008					X		
Baofeng Huo et al 2008				X			
Andreas et al 2008	X					X	
Alexander et al 2008				X			
Panayides et al 2007				X			
M.N. Qureshi et al 2007				X			X
Harry K.H. Chow et al 2007					X		
Elten Briggs et al 2007				X			
Pietro Evangelista et al 2006					X		

Mohan, B. S. S. a. R. (2006)							X
Kwok Hung Lau, J. Z. (2006).						X	
Halldo´rsson, A. r. (2006)				X			
A. Michael Knemeyer, P. R. M. (2005).				X			
Skjøtt-Larsen, r. H. r. a. T. (2004)				x			
Richard Wilding et al 2004		X					
Lieb, D. R. (2004).					X		X
Janne Huiskonen*, T. P. (2002)				X			
Brian J. Gibson et al 2002				X			
Hoek, R. I. v. (2001).	X						

6.4 3PL OUTSOURCING FRAMEWORK – A SINGLE-CASE STUDY

Given the previous knowledge within the topic and the objectives of the paper, a single case was selected for the study. The case consists of a dyadic relationship between a buyer and a provider of logistics services.

Company X is leading Oil & Gas Company worldwide and located in the Eastern Province of Saudi Arabia. It has internal customers located all over the Saudi Arabia in terms of refineries, plants and oil wells etc. The company has many suppliers all over the world for different oil and gas related products and parts such as pipes and cables etc. Material supply division is responsible for all the company's logistics activities from all over the world and inside kingdom. Mainly, it deals with procurement, inventory management, warehousing and transportation activities.

The description of the case is based on the 3PL process outsourcing framework derived from a comprehensive literature review. The case is described according to four phases defined in the framework i.e. Decision making phase, selection phase, contracting and relationship management.

6.4.1 3PL BUYER'S EXPERIENCE

6.4.1.1 Phase 1: Decision Making Phase

Initially, COMPANY X was performing all its logistics activities in-house or with the help of small local transportation companies. Due to increase in business and pressure to focus on core business and also increase in the operational cost of logistics, COMPANY X was quite familiar with the fact that they are not performing logistics functions economically and efficiently. However, Company was reluctant to outsource their logistic due to many reasons i.e. Critical nature of their business such as roads, infrastructure and communication problems as most of their refineries and plants are located in deserts and remote areas, market immaturity, government rules and regulations as it is not only a government based company but are of strategic significant to kingdom also due to oil.

The motive behind the outsourcing at COMPANY X was a general discussion in a meeting of top management of how to become more efficient in the transportation, reduce costs and create more space on the remote areas occupied by warehouses. Several functions were considered, but transportation and warehousing were targeted for outsourcing because they were time and space consuming, could not be considered as core competencies and did not

demand experience. The management took the decision that if outsourcing decision for transportation and warehousing will go right, further functions will be considered to outsource in the future. The material supply division prepared a Procurement plan in which several issues and possible effects associated to outsourcing decision were considered, Such as selection of supplier locally or globally, in-house logistics resources and capabilities, in-house logistics cost and effect of outsourcing on employees. Procurement plan was presented in the meeting of top management and various decisions were made on above issues, such as to choose supplier from global market that has already a developed infrastructure and experience in the kingdom. In this way, COMPANY X can not only learn from their international experience but takes advantages of their advanced technology and information systems. Also, it was decided to retrain all employees in the organization and relocate them to different departments.

6.4.1.2 Phase 2: 3PLs Selection Phase

After announcing and asking for bids, many suppliers showed up to offer their services. All suppliers were evaluated through a multi scoring procedure developed by company including quality management, delivery precision, technology competence, price, and general impression. The evaluation was made by cross functional team consist of technical experts and subject matter experts. After making decision, final list of suppliers were presented to top management team and based on bids, lower cost supplier was selected.

6.4.1.3 Phase 3: Contracting

After selecting final supplier, contract was made between both parties. All legal clauses were considered and reviewed by law department, contracting department and subject matter experts to have win-win and balanced contracts. Service cost was also determined such as cost per mile, cost per transactions during normal and emergency situations etc.

6.4.1.4 PHASE 4: RELATIONSHIP MANAGEMENT

During the transfer of the process and even after that, various issues and problems were encountered due to many factors such as local based customers located on remote areas, difficulties in access to refineries and local plants, lack of expertise of supplier, local manpower issues such as cultural issues and carelessness in performing jobs by local labor force, irresponsibility, absenteeism rate, language barriers etc. This resulted in delivery failures, loss of material and customer dissatisfaction. The international service provider had

to face various business issues such as binding with government regulations for local manpower hiring only, communication problems both in terms of language and due to infrastructure, such as lost of GPS or tracking and tracing system with truck drivers due to infrastructure problem in desert areas.

Another problem arises from the information system used by provider. Due to unawareness about system, many problems raised and at one stage COMPANY X got frustrated. Also, due to not considering flexibility and conflict resolution mechanism in contract, many hidden cost appeared to both parties disputed were made by both parties.

COMPANY X has taken various initiatives to handle such problems and issues. And due to these, situation became stabilize and process got improve than before.

1) Establishment of joint working team to handle routine issues and problems such as financial management issues, contracting issues such as hidden cost , adding value services and service level increment, training and development issues. Due to that step, conflict resolutions mechanism was determined. Also, service level and delivery lead time was not initially defined in contract; it was defined and set according to different zones.
2) Close collaboration with 3Pl service provider is made in terms of investment on provider's employees such as training, education, supply chain certification program, scholarships for provider's employees from COMPANY X.
3) Initialization of 3PL service provider-Supplier collaboration program. One initiative is Weekly visits of suppliers with a team included 3PL logistics. Due to that various complaints were solved such as some time 3pl provider complain about supplier's lateness in preparing stuff, or supplier's complain about provider's late arrival to pickup stuff
4) To handle customer's issues and complaints, many initiated were taken, such as Customer Forum ,Free customer service number, Tracking and tracing system, Helpdesk etc

6.4. 2 COUNTERPART EXPERIENCE

COMPANY Y is leading logistic Company worldwide and it has customers located all over the Saudi Arabia as well. Currently, COMPANY Y is in the arrangement of leading Petroleum Company X and involved in their logistic activities such as transportation and warehousing.

A brief summary of meeting is presented below. For the sack of convenience, the important points extracted from meeting are being classified into three main phases.

6.4. 2.1 Phase 1: Pre-contracting Phase

COMPANY Y is providing logistic services in kingdom by forming alliance with local subsidiary OLAYAN and EXEL. Currently, COMPANY Y is focusing into three main sectors, Energy, life science and automotive. The decision for making partnership with other firms usually results from two approaches.

1) Hunting approach such as seminar, conferences and symposiums
2) Organically grow account through an issue of contract

6.4. 2.2 Phase 2: Selection

It is abundantly clear for them that through business alliances, they would able to find business in Saudi Arabia. Through that relationship they discovered that Saudi COMPANY X is looking to outsource their business MRO operations. COMPANY X invited 16 groups for tenders and eventually EXEL Saudi Arabia won the tender.

Besides providing logistic services to firms and organization in KSA, company A also helps firms and organization to determine their in-house logistic capabilities and logistic cost. Regarding the estimation of cost of the services, COMPANY Y has an efficient process of calculating and determining different costs such as total landed cost etc.

6.4. 2.3 Phase 3: Contracting

After making final decision for 3PL partnership with its customer, contract was made between both parties. All legal clauses were considered and reviewed to have win-win and balanced contracts. Service cost was also determined such as cost per mile, cost per transactions during normal and emergency situations etc.

Important elements that need to be considered in Contract are

- Contract should be focused. The more focus the contract is, the better relationship would be

- Contract should be flexible
- Contract should be more than legal aspects. It must be tool for building, supporting and helping relationship
- Problem solving mechanism has to be a part of contract
- Both parties must Understand each other requirements, and partnership's objectives
- Scopes and requirements have to be clearly understood.
- Certainty is very important in contract
- Termination clause or contingency statement should be based on some logical issue that allows either party to adjust for unexpected events rather than minor and illogical issue such as cancellation of contract or agreement because of late delivery or not appearing of truck on site etc

6.4. 2.4 Phase 4: Relationship management

"3PL relationship between customer and provider are very similar to marriage relationship between man and woman". Director commented. " It takes a while to develop trust between both parties "

During the transfer of the process and even after that, various issues and problems were encountered due to many factors such as complexity of COMPANY X supply chain, local based customers located on remote areas, difficulties in access to refineries and local plants, lack of expertise of supplier, local manpower issues such as cultural issues and lack of experience, irresponsibility, absenteeism rate, language barriers etc. This resulted in delivery failures, loss of material and customer dissatisfaction. Either party did not understand about each other's requirement. There was an acceleration of process by SAUDI COMPANY X, so they pull forward COMPANY Y EXEL a lot. On the other hand, COMPANY Y-EXEL in effort to please their customer had to compromise on all demands.

Another problem arises from the information system used by provider & customer. Due to unawareness to system, many problems raised. Logistic Business and supply chain business that move so far are based on IT plate forms, such as MRP ERP. Integration of these platforms together historically is very difficult.

Also, COMPANY X deployed very experience logistician in sites for supervision and inspection purpose. On the other hand, COMPANY Y employees due to lack of experience could not collaborate well with their counterpart.

Also, due to not considering flexibility and conflict resolution mechanism in contract in beginning , many issues appeared and ended with hidden costs for both parties and were solved with disputed made by both parties.

Various initiatives have been taken to handle such problems and issues. And due to these, situation became stabilize and process got improve than before.

5) Establishment of joint working team to handle routine issues and problems such as financial management issues, contracting issues such as hidden cost , adding value services and service level increment, training and development issues. This joint team has different levels, such as Vice president Levels to handle strategic issues, Managerial level for resolving tactical issues. Within 3 months of joint meetings, both parties finalize all important issues and aspects of relationships. 200 focused items were considered and 73 initiatives were proposed. 55 initiatives were implemented and 10 of them partially implemented. Remaining items were not considered changeable
6) Four main elements are significantly important for effective relationship management. These are **trust, Process, Human resource and Workable infrastructure**.
    I. An important element in building and maintain trust is to not having too much people involved in process. Building trust level is not a transactional process but it increase commandly when both understand each other's businesses, Performing according to contractual arrangements, having respect of each others , having good commercial framework, transparent relationships are key to develop trust level.
    II. Process: Jobs need to be performed according to designed SOPs. SOPs when not effectively communicated or implemented create problems and issues. Process need to be written, need to be understood, need to be implemented, need to be changes as environment changes.
    III. Workable infrastructure in terms of enablers, vehicles, warehouses, roads play significant roles in relationship developments.
    IV. COMPANY Y made the vision of developing and implementing localization instead of hiring expatriates or hiring senior personal from other countries. Due to that policy, COMPANY Y achieved the record level of 90% localization which is much higher than not only other Kingdom's organizations but also higher compare to other branches of COMPANY Y worldwide. Due

to their employees development program, COMPANY Y able to improve their services. Example would be absents rate of employees. It was 40% in 2007 and 15% in 2008. However, it was decreased to 7% in 2009 and finally in 2010 end to less than 1 percent. That definitely shows the effectiveness of their development program.

6.5 CONCLUSION

In this chapter, a general outsourcing process framework has been derived by thorough review to determine all important aspects and elements in 3PL outsourcing processes. The framework based on systematic arrangements of all important elements and aspects in 3PL outsourcing process previously proposed in literature along frequency of citations and frameworks proposed previously.

The derived framework has successfully applied to empirical data obtained from leading organizations in the region. These data was achieved through one to one meeting with top management of these organizations. It has been analyzed that which of the phases and activities in the proposed framework are being used by these firms and what and when logistics factors are considered by the companies during the process.

CHAPTER 7

3PL RISK MANAGEMENT PROCESS

Overview

The main objective of the chapter is to derive a framework for 3PL risk management that will not only identifies various risks exist in different stages of logistic outsourcing process but proposed their respective treatment strategies along tools and methods require for each phase

7.1 INTRODUCTION

In previous chapter, we already mentioned benefits, advantages and various motivational factors for 3PL outsourcing processes from literature review and a conducted case study. However, 3PL relationships are not always successful. According to a study "logistics outsourcing has become a source of corporate failure and disappointment also" (Boyson, et al 1999). A significant proportion of the respondents from different surveys conducted in different countries and industries indicated that they had to modify their logistics arrangements and take previously outsourced functions back in-house (Lambert et al 1999). Furthermore, it is reported that 55% of logistics alliances were terminated after three to five years. Similar results were obtained in a study by the Outsourcing Institute where it was found that more than half of third-party partnerships had failed. It has been claimed that "many 3PLrelationships are increasingly complex and management of those relationships is quite challenging to both parties" (Gulisano et al 1997) and (Foster et al 1999).

A question may arise here that what went wrong in these unsuccessful cases. Are these problems indicating that 3PL strategy need fine tuning or may not be appropriate for some organizations in some environments? Or there would be some fundamentals characteristics, firms forget to follow or implement that result in failure of alliance. Or if they follow any fundamental procurement framework, they may not be able to identify risks associated to 3PL

process. Or even they would able to identify risks but could not able to identify appropriate risk mitigation strategies.

The main objective of the chapter is to derive a framework for 3PL risk management that will not only identifies various risks exist in different stages of logistic outsourcing process but proposed their respective treatment strategies along tools and methods require for each phase of the process.

The rest of the chapter is organized as follows. We first present the methodology of research. The scholarly work done in 3PL risk management will then be presented stage by stage. Finally, the report is concluded with main findings and discussion for future research opportunities.

7.2 APPROACH AND METHODOLOGY

In this section, we will examine the newly released International Standard ISO 31000 "Risk Management – Principles and Guidelines" and explore its applicability in 3PLs. To the best of our knowledge, the above mentioned framework is not implemented to 3PL context until now.

The new standard consists of the seven process steps

I. Communication and consultation
II. Establishing the Context;
III. Risk Identification,
IV. Risk analysis,
V. Risk evaluation,
VI. Risk treatment;
VII. Monitoring and review

Risk Management process will be implemented on all the phases of 3PL outsourcing framework. Risk identified already in the Literature and through case study approach will be analyzed and methods and tools for risk identification and evaluation will be proposed. Also, various risk treatment strategies reactive or proactive in nature will be proposed.

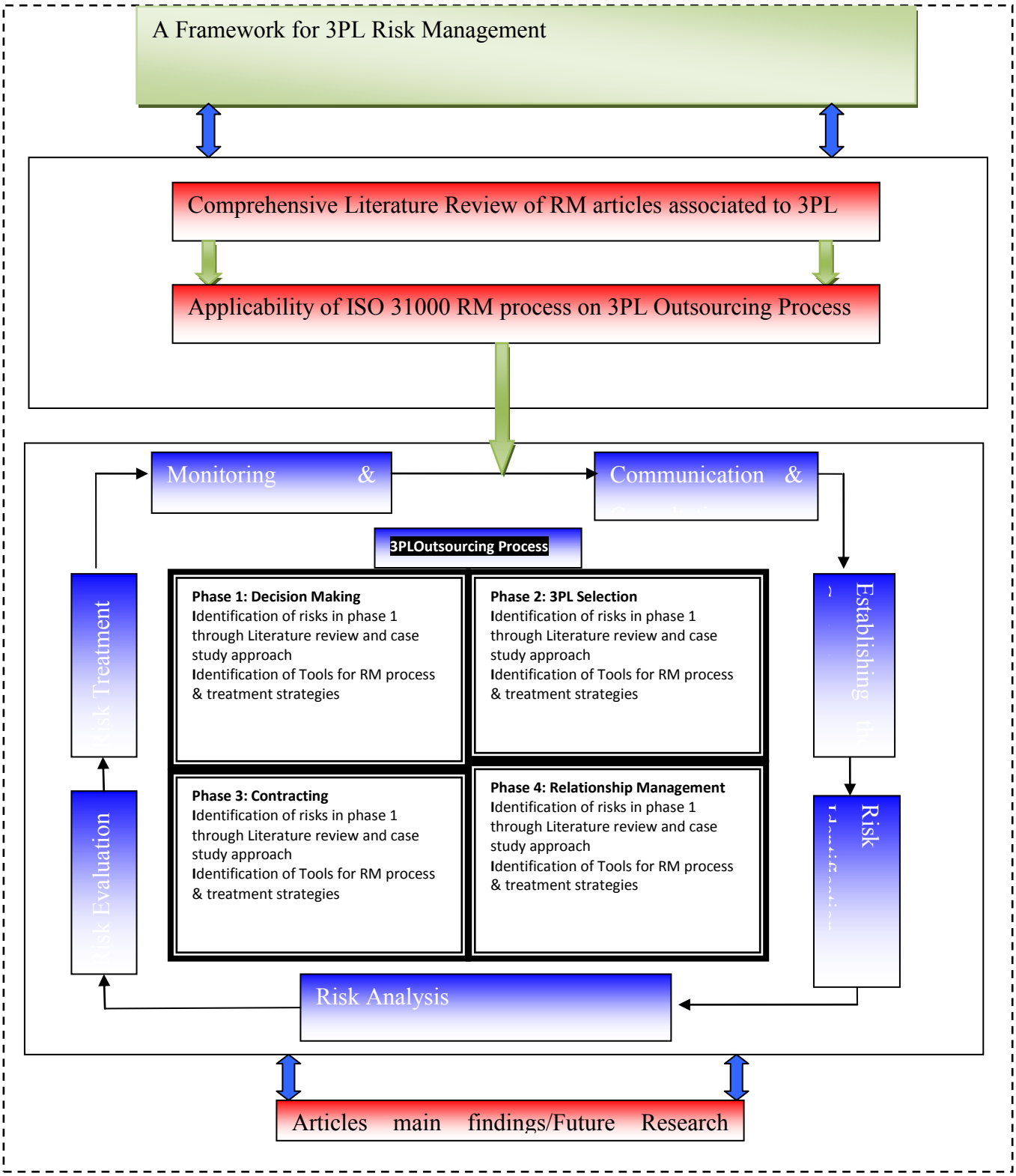


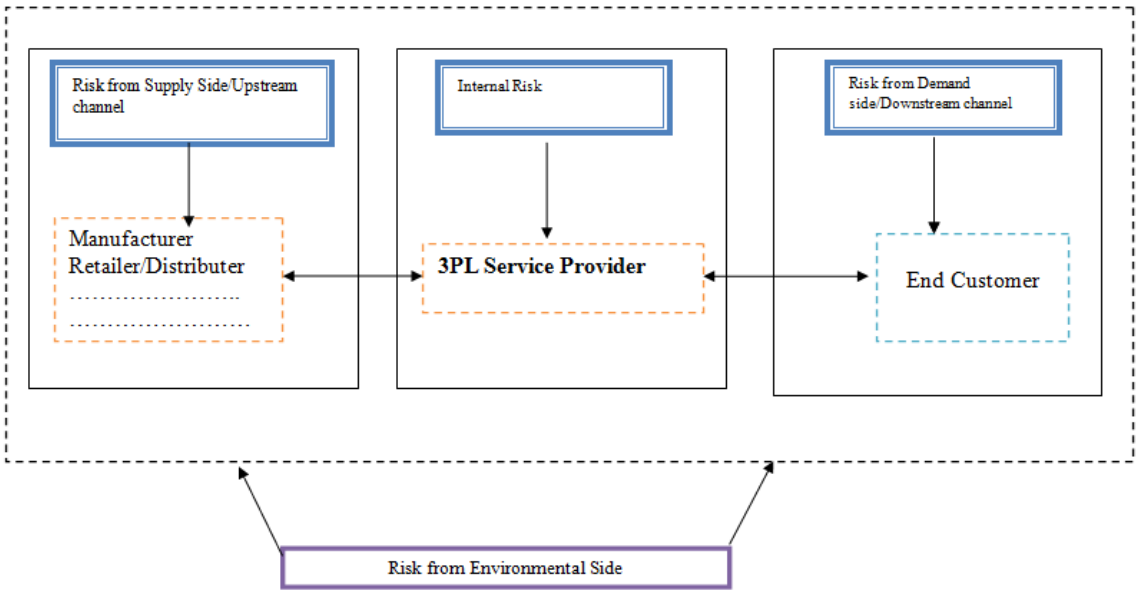
Fig 34: A framework for 3PL Risk Management

7.3 RISK MANAGEMENT PROCESS

A brief summary of each stage in ISO 31000 risk Management process is presented.

7.3.1 RISK IDENTIFICATION:

Many risk classification are already analyzed and discussed by many authors.(Tang et al 2006) categorized supply chain risks into operations and disruption risks. Another classification is provided by (chopra and sodhi et al 2004) Where author categorize risks into delay of material from suppliers, systems breakdown and large forecast error etc. Readers are referred to table 14 for more classification available in literature. We have adopted risk classification provided by[Ref] i.e supply side risk, demand side risk, internal risk and environmental risk. Supply side risks arise from supplier side such as disruption of supply, inventory and schedule issues and incoming delays. Demand side risks come from downstream side of supply chain in the form of change in customer demand or forecasting error. Internal risks are refereed to organizational internal risks such as process risk, control risks etc. Environmental risk also known as external risks arise due to external factors such as catastrophic events, government regulations etc. [Manuj et al 2008].



There are various articles in the literature that specifically address risks associated to 3PL process. A brief summary of risks with articles is following.

Loss of control to third-party provider(s) cited by (Bardi and Tracey, 1991); (Bowman, 1995); (Byrne, 1993); (Cooke, 1994-b); (Lynch *et al.*, 1994); (Richardson, 1993-a), (Bradley, 1995-a), (Ellram and Cooper, 1990) Cited by (Razzaque et al 1998) and (lau et al 2006). lack of responsiveness to customer needs is also cited as a problem of outsourcing (van Damme and Ploos van Amstel, 1996). (Ellram and Cooper, 1990). (Zeng Xiangyun 2004) (lau et al 2006). Difficulty of assessing the savings to be gained through outsourcing, the firm's logistics people apprehensive about their job security was identified by (Cooke, 1988); (Muller, 1991-b)

lack of advanced information technology linking manufacturer, carrier, warehouse, and customer operations has caused hindrance (Byrne 1993) Cited by (Razzaque et al 1998) (Bradley, 1995-a). Cited by (Razzaque et al 1998), (Cui Nanfang et al 2006) (Wei Zhong et al. 2005) (lau et al 2006) (Sohail et al 2005).

Risk of not gaining expected objectives or performance level is cited by (Bradley, 1995-a). Cited by (Razzaque et al 1998) (Cooke, 1988); (Muller, 1991-b) (XuShu, 2003). (Lim 2003) , Cited by (lau et al 2006). (Gadde and Hulthen et al 2009) identified two important risk sources that causes many relationships to fail. Insufficient analysis of the potential effects of outsourcing and - problems in the implementation of TPL-arrangements. (Sohail et al 2005) on his analysis on 3PL practices in Saudi Arabia has identified many risks and issues. Issue in teaching the contract logistics firm about the company's policies and business requirements (21 percent); issue in reaching agreement on service definitions (16 percent); and overcoming employees' resistance to changes (9 percent). Incompatibility of information systems, coordination and integration between the company and the contract logistics firm; price negotiations; and the contract logistics firm's insufficient understanding about the company's operations. (Kenneth et al 1996) cited various issues such as unrealistic understanding about the job between both parties, over-promise of service provider and management resistance from buyers side, disappointed results in terms of financial and profit aspects, unable to renegotiate the contract, loosing interest in providing good service, service failures , and an orderly procedure for separation is not specified in the agreement.

Other cited risks are possibility of inefficient management, latent information asymmetry, loss of logistic innovative capacity, and hidden cost etc. Some of the measures he proposed were customer relationship management, information sharing mechanism etc .

(lau et al 2006) identified Poor customer service, Local protection regulations Higher logistics cost and damage rate, Limitation in choices of suppliers Lack of overall post-outsourcing review Failure in knowing if the outsourcing process is working as planned, Failure in identifying areas of improvements or changes, Lack of capable service providers Less than expected service quality, Failure in realizing expected cost reduction or capital, investment reduction, Hindrance to further outsourcing of activities, Loss of control Inconsistent service quality, Inefficiency in communication, Poor transportation and IT infrastructure Higher logistics costs, Unreliability in pickup and delivery time, Higher rate of loss and damage of goods, Loss of control, Loss of core competencies, Risks of alienating customers, Loss of critical skills, Loss of competitive advantage, Increased number of competitors, Inadequate capabilities of service provider Loss of competitive advantage, Loss of market share , Loss of flexibility Reduced responsiveness, Risks of alienating customers, Failure to realize hidden costs of contract Increased operating cost , Difficulty in obtaining organizational support Increased chances of failure , Indecisiveness on which activities to outsource, Increased chances of failure, Inadequate cost and benefit analysis systems, Lower return on investment, Loss of competitive advantage, Fear of job loss Increased resistance to change, Lower staff morale Cited by (lau et al 2006).

(konstantinos et al 2008) cited risks from literature and classified them into three main types.

Strategic Risks: Loss of control over the logistics function , Loss of customer contact, Loss of in-house logistics capability, Leakage of sensitive information , Lack of responsiveness to customer needs, Employee resistance to change

Financial Risks: Unrealistic fee structure and financial loss, Cost reduction offset by provider margin, Dependence on service provider/ opportunism, Cost saving assessment difficulties

Operational Risks: Poor IT capabilities, Poor personnel quality, Poor customer service, Time and effort put on logistics is the same, Inadequate expertise, Inability to handle special product needs, Disruption to operations, Loss of customer feedback

(Lim 2003) cited various risks from literature , financial risk, performance risk, bodily risk, psychological risk, social risk and time-loss risk By (Jacoby and Kaplan 1972),financial risk, perceived performance risk, perceived social risk, perceived physical risk,perceived psychological risk, perceived time-loss risk, perceived personal risk, perceived privacy risk and perceived source risk by (Stone and Gronhaug 1993)

(Wei Zhong et al. 2005) believed that risks existing in logistics outsourcing include management risk, information risk, financial risk and market risk.

(Li Songqing 2005) believed that, an enterprise that uses the third party logistics faces the risks of partial or complete loss of control rights, customer relation management, enterprise strategy disclosure, associate operation, opportunism, etc

(Zeng Xiangyun 2004) mentioned some of the risks such as both parties do not reach a common understanding, the supplier does not meet his commitments, there is a contradictory emotion inside the enterprise, it is difficult to satisfy the end customers' needs, termination clauses are lacking for profit loss, etc. (Cui Nanfang et al 2006) found limited rationality, contractor's opportunism, outsourcing transaction "locking", etc., and those existing in execution phase mainly concern moral risk, coordination issues, potential after-cost, etc as potential 3PL risks.

(XuShu, 2003) mentioned contract cost increase caused by disputes at law, proceedings and difficulty in contract negotiation, hidden cost increase such as service and management cost increase, etc. service quality decline, losing expertise and innovation ability and weakening the organizational competence as 3PL risk sources. Other risks identified were risk that the service performance of the 3PL provider will erode over time (La Londe and Cooper 1989.117),

(Lynch, 2000, p. 186) found that another important issue in 3PL relationship management is what should be measured and methods of measurement.

Many authors proposed various tools and techniques for different stages of Risk management process.i.e Risk Identification, Risk evaluation and Risk treatment. The tools or approaches are not necessary belongs to 3PL literature but could be from general SCRM issues. The goal of risk identification is to develop a detailed list of risks that affect the objectives of Supply chain management. It includes the identification of risk source from within or outside of the Supply chain. A variety of techniques are presented in the literature by academicians. The most important technique used by in literature is method of surveying/questionnaire and interviews. Following article discussed (Jiang et al 2009), (Tuncel et al 2009), (X.Li&I.Barnes et al 2008), (Loosemore et al 2008), (Thun et al 2009), (A.oke et al 2009), (Tsai, M. C et al 2008), (Breen, L. 2008), (A. Brun et al 2006), (Lim, S. H.et al 2009),(S.M.Wagner et al 2008),(Autry&Bobbit et al 2008). Another famous tool is delphi technique used by (Tsai, M. C et al 2008),(Hameri, A. P. 2009). Another important risk identification tool is Action Research(AR) used by (Tobias 2008). Action research is a qualitative research technique in which the researcher actively participates in and influences ongoing organizational processes, but intermittently steps out of the system to obtain a

broader perspective (Ottosson, 2003). The researcher can thus be described as an outside agent, taking action and creating knowledge at the same time, who acts as a facilitator in an organization (Coughlan and Coghlan, 2002). Some of the quality tools such as process mapping and cause and effect diagram are used by (Kumar, S 2008), (Kumar, S 2007) for identification puposes.The concept of simulation software used for identification is also gaining importance. Different real life Scenarios are simulated and risks are identified such as used by (Briano 2010-b).Another way of risk identification is to investigate different databases consists of Literature review, electronic resources and newspaper etc. such as done by (Hamid Mohtadi 2009). Supply chain vulnerability map is also useful in order to detect risks at supply chain level. (Blos et al 2009). Other tools used are expert opinion combined with historic data or combined with decision maker's opinion, Game theory , catastrophe modeling and real option approach.(knemeyar 2009).

Table 26: Risks Cited in Literature

Risks cited by Authors	Reference
Loss of control to third-party provider(s)	(Bardi and Tracey, 1991; Bowman, 1995; Byrne, 1993; Cooke, 1994b; Lynch *et al.*, 1994; Richardson, 1993a) Cited by Razzaque et al 1998
lack of advanced information technology linking manufacturer, carrier, warehouse, and customer operations has caused hindrance	Byrne (1993) Cited by Razzaque et al 1998
losing control, losing touch with important information, failure to select or manage providers properly, unreliable promises of the providers, their inability to respond to changing requirements, their lack of understanding of the buyer's business goals and difficulty of changing providers have also been cited as potential problems by their users	(Bradley, 1995a). Cited by Razzaque et al 1998
difficulty of obtaining organizational support	(Bowman, 1995)
Management's lack of confidence in an outside company	Cooke, 1994b; Maltz, 1995
Difficulty of assessing the savings to be gained through outsourcing, the firm's logistics people apprehensive about their jobsecurity	Cooke, 1988; Muller, 1991b
loss of control over the logistics function and loss of in-house capability and customer contact	(Ellram and Cooper, 1990).
lack of responsiveness to customer needs is also cited as a problem of outsourcing	(van Damme and Ploos van Amstel, 1996).
unrealistic fee structures proposed by service providers	(Ackerman, 1996) Wilding and Juriado, 2004
assert that the buyers are keenly concerned about loss of control over the materials flow in the logistics channel	LaLonde and Cooper (1989, pp. 116-7)
But how the buyer can assess the cost performance of the TPL provider An initial step is to operate with transparent	Lynch, 2000, p. 89)

fee structures such as cost plus percentage,activity-based costing, and cost plus management fees (	
what should be measured and methods of measurement	(Lynch, 2000, p. 186).
the buyer is "continuity of services", i.e. the risk that the service performance of the TPL provider will erode over time the buyer may prevent such a situation by emphasizing a close working relationship, good communication, and openness. But seen from the provider's perspective, the types and levels of investments required to achieve such a relationship might induce a certain risk. This applies especially if the investment, or even accumulated experience, is specific to the buyer's operations and hence difficult to transfer to other accounts	LaLonde and Cooper (1989:117),
contract cost increase caused by disputes at law, proceedings and difficulty in contract negotiation, hidden cost increase such as service and management cost increase, etc. service quality decline, losing expertise and innovation ability and weakening the organizational competence	(XuShu, 2003).
limited rationality,contractor's opportunism, outsourcing transaction "locking", etc., and those existing in execution phase mainly concern moral risk, coordination issues, potential after-cost, etc	Cui Nanfang et al (2006)
both parties do not reach a common understanding, the supplier does not meet his commitments, there is a contradictory emotion inside the enterprise, it is difficult to satisfy the end customers' needs, termination clauses are lacking for profit loss, etc	Zeng Xiangyun (2004)
believed that, an enterprise that uses the third party logistics faces the risks of partial or complete loss of control rights, customer relation management, enterprise strategy disclosure, associate operation, opportunism, etc	Li Songqing(2005)
believed that risks existing in logistics outsourcing include management risk, information risk, financial risk and market risk	Wei Zhong et al.(2005)
found that there were six kinds of risks including financial	Jacoby and

risk, performance risk, bodily risk, psychological risk, social risk and time-loss risk	Kaplan(1972), Stone and Gronhaug (1993)
has summarized the previous study on risk perception, and classified the risks into nine aspects. The nine kinds of risks respectively are perceived financial risk, perceived performance risk, perceived social risk, perceived physical risk,perceived psychological risk, perceived time-loss risk, perceived personal risk, perceived privacy risk and perceived source risk.	Lim(2003)
Strategic Risks: Loss of control over the logistics function , Loss of customer contact, Loss of in-house logistics capability, Leakage of sensitive information , Lack of responsiveness to customer needs, Employee resistance to change **Financial Risks**: Unrealistic fee structure and financial loss, Cost reduction offset by provider margin, Dependence on service provider/ opportunism, Cost saving assessment difficulties **Operational Risks**: Poor IT capabilities, Poor personnel quality, Poor customer service, Time and effort put on logistics is the same, Inadequate expertise, Inability to handle special product needs, Disruption to operations, Loss of customer feedback	Ellram and Cooper et al 1990, van Damme and Ploos van Amstel et al 1996 , Konstantinos et al 2008, Ackerman, 1996, Wilding and Juriado, 2004, van Laarhoven et al., 2000, LaLonde and Cooper (1989, pp. 116-7), Lynch, 2000, p. 89 Cited by konstantinos et al 2008
Loss of control, Loss of core competencies, Risks of alienating customers, Loss of critical skills, Loss of competitive advantage Increased number of competitors, Inadequate capabilities of service provider Loss of competitive advantage Loss of market share , Loss of flexibility Reduced responsiveness Risks of alienating customers, Failure to realize hidden costs of contract Increased operating cost , Difficulty in obtaining organizational support Increased chances of failure , Indecisiveness on which activities to outsource,	Cited by lau et al 2006

Increased chances of failure, Inadequate cost and benefit analysis systems Lower return on investment, Loss of competitive advantage Fear of job loss Increased resistance to change, Lower staff morale	
Lack of capable service providers Less than expected service quality, Failure in realizing expected cost reduction or capital investment reduction, Hindrance to further outsourcing of activities, Loss of control Inconsistent service quality Inefficiency in communication, Poor transportation and IT infrastructure Higher logistics costs, Unreliability in pickup and delivery time, Higher rate of loss and damage of goods Poor customer service, Local protection regulations Higher logistics cost and damage rate, Limitation in choices of suppliers Lack of overall post-outsourcing review Failure in knowing if the outsourcing process is working as planned, Failure in identifying areas of improvements or changes	lau et al 2006
teaching the contract logistics firm about the company's policies and business requirements (21 percent); reaching agreement on service definitions (16 percent); and overcoming employees' resistance to changes (9 percent). Incompatibility of information systems, coordination and integration between the company and the contract logistics firm; price negotiations; and the contract logistics firm's insufficient understanding about the company's operations were also the other impediments mentioned by respondents.	Sohail et al 2005
insufficient analysis of the potential effects of outsourcing and - problems in the implementation of TPL-arrangements.	Gadde and Hulthen et al 2009
possibility of inefficient management, latent information asymmetry, loss of logistic innovative capacity, and hidden cost etc. Some of the measures he proposed were customer relationship management, information sharing mechanism	16 et al

etc	
The buyer and seller have not reached a realistic understanding about the job to be done. • The seller has over-promised and is unable to deliver on that promise. • One or more managers at the buyer's company do not want to make the relationship work and maintain a well-hidden desire to see it fail. • The seller has discovered that he/she is losing money in the relationship and, since he/she cannot renegotiate the contract, he/she loses interest in serving his/her customer. • Service failures have become intolerable for the buyer. • An orderly procedure for separation is not specified in the agreement.	Cited by Kenneth et al 1996

7.3.2 RISK ASSESSMENT:

Once risks identified, they must be then assessed as to their potential severity of loss and the probability of occurrence. The process of risk assessment is comprised of analyses phase where usually identified risk at previous stage are assessed not only to prioritize them in term of criticality but also to understand the relationship between various aspects such as checking interdependencies between risks and practices etc. We have reviewed those techniques which help to assess the risks

Risk can be assessed and prioritized according to four phases of 3PL outsourcing process that comes one by one. Each phase must be considered and analyzed in such a way that all potential risk must be eliminated right away during the phase. The tools used for that purpose are very similar to risk identification phase. Such as the Delphi method or questionnaire/surveying etc. These techniques are used for assessment purpose by (M. Loosemore et al 2008),(P.Trkman et al 2009), (A.oke et al 2009), (Breen, L. 2008),(**Voss, M. 2009),** (Lim. S. H.et al 2009). The AHP is another method used to assess the criticalities affecting the objectives used by (Tobias 2008),(Tsai, M. C et al 2008),(Barbara et al 2006) and (Breen, L. 2008). Other qualitative tools use for assessment purpose are Risk matrix and risk register by (omera khan et al 2008-a), Probability impact matrix by (J.-H. Thun et al 2009), Multi criteria scoring procedure and FMEA by (Jennifer et al 2008) and (G.tuncel et al 2009) respectively. Large organizations are using software tools in order to assess different risks when contracting and forecasting demands supply etc. Such as horizon demand scenario software, HP risk component cost forecasting and HP risk contract valuation software used by HP (Nagali, V.et al 2008). Simulation is no doubt an important way to assess the risk such as used by (Briano 2010-b)and (L. Jacxsens et al. 2009). Other important tools and ways found in the literature are extreme value theory used by (Hamid Mohtadi 2009), , conjoint analysis used by (**Voss, M. 2009)** , probabilistic methods used by (**A. Brun et al 2006)** ,expert evaluation used by (Hameri, A. P. 2009) and supply chain vulnerability map used by (Blos et al 2009) Factorial Analysis/LOGIT by (Jiang et al 2009) , Petri net tool by (tuncel 2009)

7.3.3 RISK TREATMENT:

Once the process of risk assessment is finished, appropriate risk management strategies can be adopted. These strategies can be classified into two main categories, Proactive Strategies

and Reactive Strategies. The Literature is full of different strategies. Some of them were classified as general. Some of them were very specific.

Table 27: 3PL Process phase wise risk classification

Phase	Risks identified
Decision making Phase	❖ Outsourcing undesirable functions versus the ones that provide greatest competitive advantage ❖ Not clearly defining goals and objectives before starting the outsource process ❖ Not establishing an effective internal baseline to measure providers against, including costs, service, and value adds ❖ Outsourcing in the international market without international operations experience ❖ Inadequate business case development for the outsourcing decision ❖ Making the decision to outsource without complete information on internal costs and processes ❖ Not considering the impact of outsourcing on other functions and areas of risk such as environmental and regulatory factors ❖ Lack of understanding the human relations and employment law requirements for an outsourcing initiative ❖ Announcing outsourcing before sufficient details have been finalized, creating morale issues ❖ Lack of risk analysis and risk assessment planning
3PL Selection Phase	❖ Not including enough resources to effectively manage the 3PL selection process ❖ Not having the proper internal skill set to effectively manage the selection process ❖ Not understanding or leveraging the benefits a Request for Information (RFI) can have in narrowing the potential provider field before entering the Request for Proposal (RFP) process ❖ Not casting one's net widely enough for potential providers of the service, and thus missing good candidates ❖ Not involving a variety of perspectives in the selection process ❖ Poorly developed and documented service or product specifications ❖ Inaccurate costing of assets that will be transferred to the service or product provider ❖ Not doing business and financial due diligence on potential providers ❖ Insufficient knowledge of service provider capacity limitations

	❖ Making the selection process a personal rather than a commercial decision
Contracting Phase	❖ Having an unrealistic timeline for any of the steps of the outsource process including start up ❖ Poor implementation planning with respect to timing of transition to service provider and demands on the organization ❖ Underestimating the time required to negotiate a Service Agreement Not fully defining an employee transition plan ❖ Not getting the operational issues resolved in the Service Agreement before moving into the legal aspects of the agreement ❖ Inadequate planning concerning information systems and interfacing with the service provider ❖ Lack of a contingency plan for major disruptions at the service provider ❖ Not putting a full communication plan into effect including escalation processes, ❖ proceedings and difficulty in contract negotiation ❖ Spending too little time negotiating the contract and pretending that the partnership relationship with the vendor will take care of everything ❖ The lawyers used by the buyer may not understand what it meant to write supplier agreements for services, but may try to use the same templates and models as they use for non-service relationships ❖ Pricing the services to be purchased in the agreements with suppliers also difficult due to the intangible nature of services. ❖ The problems are concerned with the importance of people and their competence for service businesses, a competence that is difficult to specify in a contract. ❖ Expectations of services are often difficult to specify, standardize and predict ❖ Difference of opinion or perception of service level of 3PL provider ❖ Vendor legally breaks (terminates or amends) the contract, leading to dispute and litigation expenses ❖ Vendors withhold or distort information to technically misinterpret contract, or to use dependence of outsourcers for price increase. ❖ Failure to realize hidden costs of contract
Relationship Management	❖ Insufficient technology development before implementation ❖ Not training the provider on critical elements of the company product line or service expectations

	❖ Not establishing an outsource relationship that has sufficient flexibility to deal with business fluctuations ❖ Initiating an agreement with a service provider that limits flexibility in the future ❖ Not considering the full impact of an outsourcing agreement on a company's financial condition ❖ Lack of internal communication ❖ Lack of incentives for provider continuous improvement ❖ Not establishing multiple touch points between the company and the provider ❖ regularly scheduled meetings, review periods, and employee communication ❖ Doing a poor job managing expectations around the go-live ❖ Expecting too much from a provider in the early months after go-live ❖ Neglecting to "flex" the outsource relationship as outsource requirements evolve ❖ Lack of a formal "lessons learned" roundtable on outsourcing in general and, specifically, established outsource relationship ❖ Problems in the Implementation of 3PL Arrangements ❖ Insufficient communications between partners leading to mistrust and misunderstanding ❖ Conflicts between the partners and within each partner company undermining the effectiveness of the relationship ❖ Lack of trust between the individuals in the partners companies increasing the tension ❖ Cultural differences between the partners companies ❖ Organizational politics ❖ Loss of customer Contact ❖ Leakage of sensitive information , Lack of responsiveness to customer needs, ❖ Unrealistic fee structure and financial loss, Cost reduction offset by provider margin, Dependence on service provider/ opportunism ❖ Time and effort put on logistics is the same, Inadequate expertise, Inability to handle special product needs, Disruption to operations, ❖ Lower return on investment ❖ Loss of competitive advantage ❖ problems of evaluating and monitoring 3PL performance, Conflicts of culture ❖ Loss of Logistic innovative Capacity, Dependence on 3PLs

Table 28: Risk Management stategies proposed in Literature

Relationship evaluation	Performance indices for logistics outsourcing. It should include both cost and service measures, should evaluate systematically the performance of integrated 3PL operations	Chuanxu Wang
Asymmetric information	Information sharing encouragement mechanism. Information technologies can be used to establish such mechanism which can be shared by both parties	Chuanxu Wang
Performance risk	Suitable performance tactics : it should be centered on characteristics of products or industries . it should be different for innovative products or industries compare to functional product or industries.	Chuanxu Wang
Customer related risk	Customer Relationship Management which includes reducing logistics service costs, strengthen customer relation, increasing customer satisfaction and loyalty, improving information quality , reducing information transmission delays and simplifying customer services processes.	Chuanxu Wang
Supplier risk from emerging market [Limited technical capability, Over capacity, Lack of customer support, poor supply chain management, Lower level of integrity of agreements, Poor control and management of their sub-suppliers' performance, Poor logistic control of sub-suppliers, Lack of customer support, Limited	conduction of supplier questionnaire covering a wide range of business dimensions of the supplier; performing a technical review; negotiating a risk mitigation plan; employing local based procurement staff; using a total cost estimate; applying a strict part qualification process	X.Li&I.Barnes et al(2008)

technical capability, Insufficient capacity (over capacity), Lack of customer support, Lack of standard quality assurance, Poor logistic control of sub-suppliers, Longer supply chain than expected, Slow reaction to issues, Poor stock management, Large fluctuation in material costs]		
Supplier Selection risk (Country risk such as political situation of country, natural or manmade caused disasters and currency convertibility risks)	AHP	R R.Levary et al(2008)
Examination of sensitivity of different sourcing policies	Payment contracts types Vs Sourcing plan	Manoj, U. V.(2009)
Supplier default dependencies, Supplier bankruptcy	supplier development with relationship specific investment and upgrade supplier's performance, creation of a backup supply base of independent suppliers such as located at different parts of worlds etc.	S.M. Wagner et al(2009-b)
Sourcing risk	FMEA and simulation tool	Canbolat, Y. B. et al 2008
Assessment of supplier risk in turbulent environment	Conceptual model for measuring supplier performance, Closer relationship with suppliers	P.Trkman et al(2009)
asset risk[information risk, loss of control, employee resistance, inactive logistic facility,] relationship risk[vendor opportunism, contractor violation, poor communication, lack of		Tsai, M. C et al(2008)

shared goals] and competence risk[poor competence leverage, poor competence in supporting customer services, poor competence protection]		
Logistics risks	Logistic Business Continuity Planning	Ojha&gokhale et al(2009)
Risk in transportation network	Strategic optimization, operational optimization, quality management tools, forecasting tools	V.S.Rodrigues et al(2010)
Supplier network complexity	market sensitivity, postponement activities and collaborative information-sharing partnerships	R. Masson et al(2007)
Supply risk	Trust and power mechanisms internal integration between purchasing and manufacturing groups, customer integration	A. Mendes Primo(2010
Supplier selection and Purchasing process in global sourcing	Purchasing process	Wendy L. Tate(2009)
	Global sourcing and network reengineering 1.a.Re-evaluating sourcing criteria and decisions in the global context 1.b.Re-evaluating supply base network design 1.c. Mapping and critical path analysis 3.Agility 3.a.Increasing visibility 3.b. Increasing velocity and Acceleration Creating a global sourcing risk management culture	

	Establishing global sourcing continuity teams 4.b. Board-led responsibility and Leadership	

7.4 3PL OUTSOURCING PROCESS RISK MANAGEMENT FRAMEWORK

7.4.1 PHASE 1: 3PL OUTSOURCING DECISION MAKING PHASE

Step	Action	Focus	Expected Outcome	Risk
1	perform strategic analysis	• Motives behind outsourcing decision • Logistic outsourcing Strategy • Types of relationship • Change in Supply chain structure • Understanding of competiveness and profitability • Customer requirement	• Clear Strategic Direction • Better Knowledge about Competitiveness and Profitability • Understanding of Customer's requirements	• Not clearly defining goals and objectives before starting the outsource process • Insufficient analysis of the potential effects of outsourcing • Not considering the impact of outsourcing on other functions and areas of risk such as environmental and regulatory factors
2	perform Core and non-core competence mapping	• Should we outsource all logistic functions or some of them? How companies determine functions that need to be outsourced?	• Understanding of Core & non core Functions • Complete understanding of functions need to be outsourced including top management approval	• Inadequate analysis • Indecisiveness on which activities to outsource
3	Perform Internal benchmarking and competence analysis	• Did a company measure In-House Logistic capability in terms of resources, employees and facilities? What are the steps involve in this? • How company Determines In-House logistic cost? What factors do you consider while determining the cost? How do you calculate total landed cost? • How do you perform a	• Complete knowledge of all resources • Knowledge of In-House cost • Thorough evaluation of in house performance • Common understanding of Process pitfalls and incentives • More visibility on 3Pls and In-house Performance Level	• Making the decision to outsource without complete information on internal costs and processes • Inadequate cost and benefit analysis systems Or cost saving assessment difficulties • Not establishing an effective internal baseline to measure providers against, including costs, service, and value adds

		comparison between In-House performance and expected outsourcing performance in terms?		
4		• What happen to company's employees in the company	• Remain in firm • Taken by 3PL • Fire	• Lack of understanding the human relations and employment law requirements for an outsourcing initiative • Announcing outsourcing before sufficient details have been finalized, creating morale issues • Lack of risk analysis and risk assessment planning
5		• How is customer affected by 3PL decision? How did you determine impact on customer • How do you share the benefits with your customer?		

Table 29:3PL Risk Management framework 1

7.4.2 PHASE 2: 3PL SELECTION

Step	Action	Focus	Expected Outcome	Risk
1	Identify Source of information	• Professional logistics networks, Management magazines and journals, 3PL providers ads (in all media) • Recommendations from business partners, Referrals from consulting firms, Internal Recommendations	Variety of selection list of professional 3PL providers	Could not able to gain the list of professional and quality 3PL providers
2	Determine 3PL Providers selection Criteria	• 3PL relationship attributes • 3PL financial attributes • 3PL Quality attributes • 3PL infrastructure capability	Development of selection criteria based on customer requirement and company's strategic objectives	• Wrong selection criteria • Not including enough resources to effectively manage the 3PL selection process • Not involving a variety of perspectives in the selection process • Insufficient knowledge of service provider capacity limitations
3	Prioritize different factors in selection criteria	Prioritize it according to firms' supply chain strategy and customer requirements	Prioritization of factors based on customer requirements and strategic objectives	• Not having the proper internal skill set to effectively manage the selection process • Poorly developed and documented service or product specifications
4	Decision tools used to select 3PL providers	Qualitative or Quantitative methods or hybrid approach	Advanced and scientific methods	• Lack of expertise • Wrong selection of 3Pl provider due to method
5	Develop & implement Selection process		Selection of best provider	• wrong selection due to wrong process • Not understanding or leveraging the benefits a Request for Information (RFI) can have in narrowing the potential provider field before entering the Request for Proposal (RFP) process • Inaccurate costing of assets that will be transferred to the service or product provider

Table 30:3PL outsourcing RM Framework -2

7.4.3 PHASE 3: 3PL CONTRACTING

Step	Action	Focus	Expected Outcome	Risk
1	What is the significance of a contract?		Understanding of strategic importance of contract	• Over trust in supplier and showing less importance to contract • Spending too little time writing the contract and pretending that the partnership relationship with the vendor will take care of everything
2	How to choose the best contract type Select suitable Contract best suits to your requirements	• Fixed Fee Contract • Incentive Based Contract • Outcome Based • Behavior Based	• Understanding of strategic importance of contract • Develop an incentive Contract with well defined performance reward and penalty clauses • Win-Win Contract	• Over trust in supplier and showing less importance to contract • Spending too little time writing the contract and pretending that the partnership relationship with the vendor will take care of everything • Wrong contract selection
3	Consult experts and lawyers to know what should be include.	• contract term (i.e. number of years); • costs per activity; • service and activities description; • service levels; • bonus payment for excellent performance;		Ill-defined contract
4	: Before making final agreement, evaluate the contract in following dimensions	• Preciseness, • Completeness, • Incentive Based, • Balanced , • Flexible		
5	How do you negotiate while contracting			• proceedings and difficulty in contract negotiation • Spending too little time negotiating the contract and pretending that the partnership

				relationship with the vendor will take care of everything
6	How do you make sure that contract is written balanced and two sided		Win-Win contract	One sided Contract Lack of a contingency plan for major disruptions at the service provider
7	How do you finalize about joint performance objectives and metrics to measure agreed to service level?		Create Joint performance Objectives clearly Finalize metrics to measure agreed-to-service levels	Expectations of services are often difficult to specify, standardize and predict Difference of opinion or perception of service level of 3PL provider
8	How to introduce flexibility in contract		an escape or contingency statement that allows either party to adjust for unexpected events	Disputes due to inflexible contract Not putting a full communication plan into effect including escalation processes Initiating an agreement with a service provider that limits flexibility in the future
9	How to realize and understand hidden costs in contract? How can we observe them?		Opportunism free contract	• Vendors withhold or distort information to technically misinterpret contract, or to use dependence of outsourcers for price increase. • Failure to realize hidden costs of contract
10	How do you determine different prices for service contracts			The problem is concerned with the importance of people and their competence for service businesses, a competence that is difficult to specify in a contract. Expectations of services are often difficult to specify, standardize and predict

Table 31:3PL outsourcing RM Framework -3

7.4.4 PHASE 4: 3PL RELATIONSHIP MANAGEMENT

Step	Action	Focus	Expected Outcome	Risk
1	implementation steps performed after signing contract	Develop Effective Transition plan Consider three main aspects: transition planning, organizational planning and transition of services	Smooth transition of services	• Problems in the Implementation of 3PL Arrangements • Insufficient technology development before implementation • Not training the provider on critical elements of the company product line or service expectations
5	important KPIs indicated by your firm for performance assessment measure and evaluate performance How do you evaluate relationships?	build effective performance monitoring system through • 3PL relationship attributes • 3PL financial attributes • 3PL Quality attributes • 3PL infrastructure capability	• Continuous evaluation of 3PL provider with right and effective KPIS on all dimensions • Decisions are being made accordingly	• Unable to determine correct KPIS, • Could not able to judge provider's service level on all dimensions
6	Different attributes of good relationship Relationship Management Mechanism	Inter-organizational planning level of control/Power in both parties? Trust Interaction communication/coordination Information Sharing Conflict Resolution Mechanism Organizational culture shared risk and reward	Equal or one sided demand forecasting or service scheduling	• Not establishing an outsource relationship that has sufficient flexibility to deal with business fluctuations • Lack of internal communication • Lack of incentives for provider continuous improvement • Not establishing multiple touch points between the company and the provider • regularly scheduled meetings, review periods, and employee communication Insufficient communications between partners leading to mistrust and misunderstanding • Conflicts between the partners and within each partner company

				undermining the effectiveness of the relationship • Lack of trust between the individuals in the partners companies increasing the tension • Cultural differences between the partners companies • Organizational politics
	What are the expected 3PL Outcomes?	• Organizational impact: Logistics system performance, Customer satisfaction, Employee Morale, • Financial impact: Improvement in sales revenue, Working capital improvement Capital asset reduction, Production cost reduction Labor cost reduction, Return on assets improvement Logistics cost reduction • Impact on business objectives related to Logistics system performance		• Doing a poor job managing expectations around the go-live • Expecting too much from a provider in the early months after go-live • Loss of customer Contact • Leakage of sensitive information , Lack of responsiveness to customer needs, • Unrealistic fee structure and financial loss, Cost reduction offset by provider margin, Dependence on service provider/ opportunism • Time and effort put on logistics is the same, Inadequate expertise, Inability to handle special product needs, Disruption to operations, • Lower return on investment • Loss of competitive advantage • problems of evaluating and monitoring 3PL performance, Conflicts of culture • Loss of Logistic innovative Capacity, Dependence on 3PLs

Table 32: 3PL outsourcing RM Framework -4

7.5 CONCLUSION

In this chapter, a risk management framework for 3PL outsourcing process has been proposed. Initially, all articles related to 3PL risk management were analyzed. We did not find any article that has addressed issues and risks in detail and provide framework to treat. However, these articles help us to identify different types of risks appear at different stages of 3PL process. After risk identifications through articles and case study, we classified them according to 3PL process outsourcing framework proposed in previous chapter. Risks are classified into 4 main phases i.e risks associated to decision making phase, selection, contracting and relationship management phase. Finally appropriate tools and strategies have been proposed to mitigate risks.

CHAPTER 8

EVALUATION OF 3PL RELATIONSHIPS THROUGH HYBRID INTELLIGENT SYSTEM APPROACH

Overview

This chapter provides generic infrastructure on relationship evaluation between buyer and provider and present various metrics as an input and output

8.1 INTRODUCTION

The neural network is an attempt to produce a computer system which can reason by trying to emulate the biological neural system that provides humans with their reasoning capabilities. Each input is multiplied by a predefined weighting factor. The output is then determined by a mathematical function *f(n)* which operates on the aggregation of the products of inputs and weighting factors. This explains how a brain cell is emulated in computational terms. It is also interesting to notice that for the same set of inputs, the output can be rather different if we provide this artificial neuron with a slightly different combination of weighting factors and *f(n)*. Although it may look rather simple, it lays the foundation to a powerful computation paradigm when such neurons are connected in appropriate topologies with suitably chosen weighting factors. Indeed, most neural network research and applications fall into the study of network topologies and determining the weighting factors

The application of Neural Network has been widely used in supply chain management. According to leung et al, the use of neural network in supply chain management can be classified as

Optimization such as transportation management, resources allocation and scheduling in supply chain management

Forecasting: This is another important area where application of neural network can be implemented such as demand forecasting or prediction of seasonal demand etc

Modeling and simulation such as discrete event simulation and dynamic systems theory

Globalization such as increasing coordination between activities happening at different stages

Decision support system such as increasing coordination between different nodes in supply chain

In a typical supply chain, companies acquire raw materials, spare parts or components, products or services from suppliers locally or globally to achieve their objectives in turbulent business environment. This process is also known as outsourcing. Similarly, when a company outsources all or some of its logistic functions to third party, the process is known as 3PL.
The appropriate Logistics network of a supply chain is being used to achieve different supply chain objectives such as cost reduction, responsiveness and improvement in profitability. Relationship management with 3PL is the most significant part of our thesis and so this paper. The use of neural network in 3PL context has been used for supplier selection before. To the best of our knowledge, there is no any application available where Relationship evaluation is performed through neural network approach. In this section, we have proposed a Novel approach for relationship evaluation between 3PL provider and buyers.
The remainder of this chapter is organized as follows. A brief literature review for 3PL with respect to neural network is presented next. After that, problem definition is introduced following the methodology for analysis.

8.2 PROBLEM DEFINITION

Relationship management is the most significant part of aforementioned proposed frameworks. In this section, we will propose a novel approach for relationship evaluation between 3PL provider and buyers. Important steps to gain this objective are

1) Identification of important key performance indicators and metrics that are used as input to any performance and relationship evaluation
2) Identification of expected output impacting factors that distinguished the successful relationship and unsuccessful relationships.
3) Development of idea based on hybrid intelligence that successfully compute the relationship between two partied based on above mentioned input metrics and output factors

We classified the process of 3PL Relationship Evaluation into 3 main elements.

8.3 RESEARCH METHODOLOGY

Identifying success metrics

Based on above classification, important success metrics that contribute to 3PL relationship will be selected such as level of trust, interaction, coordination and information sharing and effectiveness of conflict resolution mechanism etc. These metrics are basically the proof to whether level of relationship between both parties is a heading to success or failures.

Performance measurement

Different KPI's can be chosen for this task. These KPI's can be different for one organization to other. Some commonly used KPI's are Profit, Sales maximization, Customer Services, Quality, total customer satisfaction, on-time delivery, zero defects, employee awareness of quality importance and many more.

Risk Management

Risk consideration in 3PL relationship cannot be neglected at all. Usually relationship is evaluated by measuring the objectives set during the decision making phase of 3PL. There are several risks involve when achieving these objectives. We can calculate the risk exposure for each risk element during risk identification phase. We can identify the impact of each risk element .I.e to what extent the risk element is impacting any or all 3PL objective. For example if risk impacted very much on any objective, we should get low probability of relationship successful.

3PL outcomes

3PL outcomes are basically those objectives or expectations from both buyer and seller that are set at the beginning. These outcomes can also be evaluated by outcome measures. These outcome measures can be different from one organization to other. However some of the common outcome measures are as follows.

Impact on customer satisfaction, Impact on logistics system performance, Reduction in capital investment in facilities, Reduction in capital investment in equipment, Reduction in investment in information technology, Impact on employee morale, Reduction in manpower cost Improvement on specific logistics function parameters, Improvement in inventory turnover rates, Improvement in on-time delivery, Increasing productivity

Selecting Impacting factors on the success metric

Those factors that have severe positive or negative impact on above mentioned success metrics will be chosen. These factors are chosen based on performance measures, risk measures and outcome measures.

8.4 MODEL DEVELOPMENT

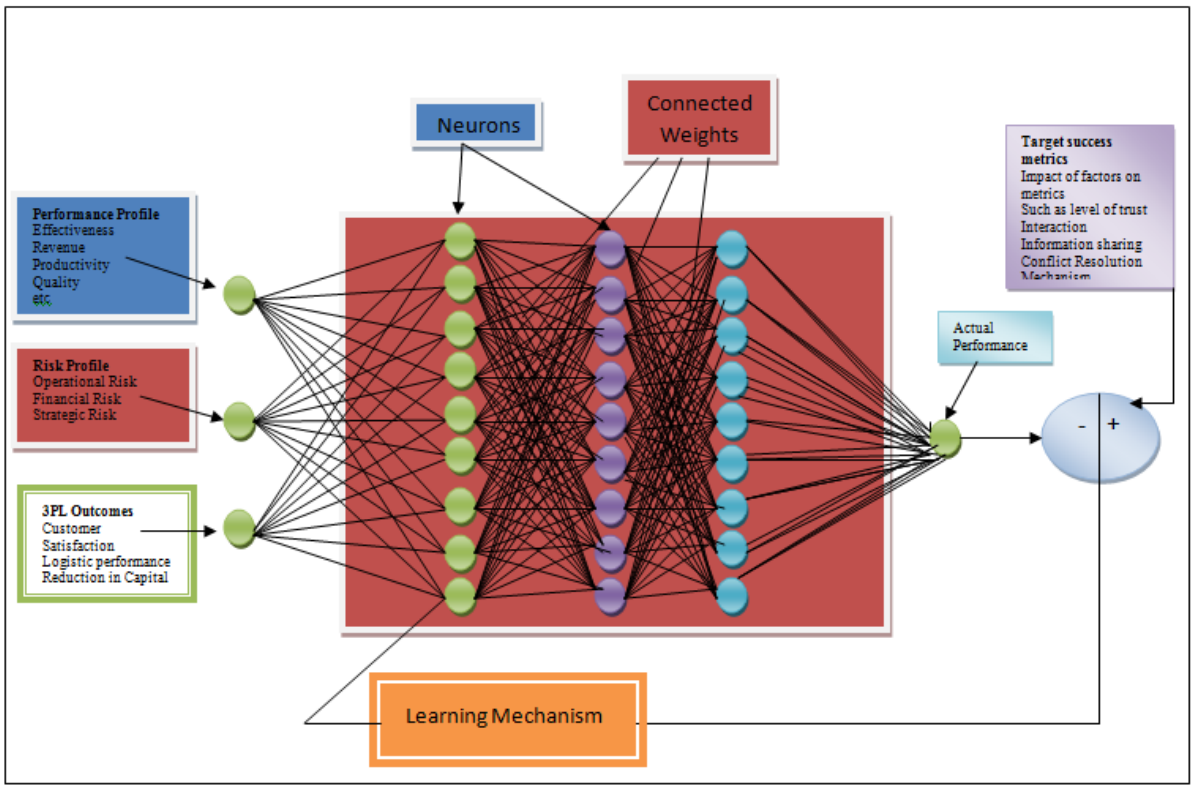


Fig: A proposed 3PL Relationship Evaluation Neural Network Model

	3PL Relationship Evaluation/Input factors																					output		Overall
Periods #	Operational effeciency				Inventory effeciency				Distribution Effeciency				Financial effeciency				Strategic Alliance relationship attributes					Performance evaluation	S.Alliance relationship evaluation	
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	trust	commitment	communication	collaboration	conflict resolution			
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Table 33: Proposedattributes for evaluation

8.5 CONCLUSION

In this section, we provide a generic model for relationship evaluation between 3PL users and providers with the help of neural network approach. The idea suggested the following

1) Determine appropriate input metrics or KPIs on which relationships need to be evaluated.
2) Determine the output factors and the benchmark performance level that determine the relationship to be successful or unsuccessful.

We have proposed the idea that input should be selected in such a way that both performance measures and risk measures are included. In performance measurement, management can think of profit, sales maximization, customer services, quality, total customer satisfaction, on-time delivery, zero defects, employee awareness of quality importance and many more. In risk measures, there are several risks involved when achieving these objectives. We can calculate the risk exposure for each risk element during the risk identification phase. We can identify the impact of each risk element .i.e to what extent the risk element is impacting any or all 3PL objectives. For example if risk impacted very much any objective, we should get low probability of successful relationship.

In the output factors, the impact of performance measures and risks measures can be calculated on following impact on customer satisfaction, impact on logistics system performance, reduction in capital investment in facilities, reduction in capital investment in equipment, reduction in investment in information technology, Impact on employee morale, reduction in manpower cost Improvement on specific logistics function parameters, Improvement in inventory turnover rates, Improvement in on-time delivery, Increasing productivity .

CHAPTER 9

CONCLUSIONS, LIMITATIONS & FUTURE RESEARCH OPPORTUNITIES

Overview

This chapter starts with a discussion of the thesis results. It then suggests future research directions.

Previous research in supply chain management has acknowledged the importance of risk management and successful 3PLs relationship management. The aim of this thesis was to investigate the current status of risk management and 3PL practices in a supply chain environment from academic & industrial's perspectives. It has been carried out through the following 5 supporting objectives.

Objective 1: To investigate current research development, to have a deeper knowledge of various tools and techniques being used in risk management processes, to identify the gap in SCRM literature and future research opportunities and finally to develop a general framework for SCRM based on ISO 3000 RM principles and guidelines.

- Contribution: Though, several researchers have already performed literature surveys on SCRM, none of them considered such a comprehensive and detailed survey and the different classification considered in this thesis. Brief summary of previously done survey articles can be found in Chapter 5 for further details. In this thesis, all aspects of research classifications are covered, such as classification based on the ISO risk management principles and guidelines, article types, topic wise, risk sources wise. There are many articles in the databases that contributed toward review of SCRM literature. However, we did not find any article that classified industrial case studies separately. Furthermore, in this section, the papers have been classified according to industrial sectors so that researcher or managers can easily identify the articles according to their own industry. A brief summary of each article along identified risks have been also presented separately for readers' convenience. Similarly, various approaches and treatment strategies adopted by industries expert or proposed by academicians have been enlisted. By considering the similar approach as for case

studies, the papers were also classified according to different quantitative models, conceptual types and risk management types so that researcher or managers can easily identify the articles according to their own needs.

Main findings:

- While most research on supply risk management has focused on the buying company, the other end of the supply chain, the supplier, has mostly been neglected. It would be interesting to investigate the perspective of suppliers, specifically for example how they may try to reduce the risks as perceived by the buyer, what their own risks are, and how they manage these risks.
- Risks affecting the relationships between firms and suppliers have also neglected. It would be interesting to investigate for complete risk free outsourcing process that discusses all important elements in the process, such as decision for outsourcing, supplier selection, contracting and relationship development. While the process of outsourcing to third world countries is growing, it would be interesting to investigate risks associated to those countries specifically. Such as China, Taiwan, India ,Thailand and Gulf countries.
- Many firms are looking for expanding their businesses to Asian countries, however there is no case study that discusses the risk sources, implications etc.
- Systematic and continuous supplier relationship evaluation based on risks and efficiency is not well addressed in the literature. It would be interesting to develop a way that would take raw data as an input and show the relationship evaluation or risk evaluation as an output. This tool can be generated through some hybrid intelligent approach such as neural network etc.
- It has been noticed that there are many metrics for measuring efficiency-related performance in a company or for suppliers; there is a strong need to devise appropriate metrics for risk exposure and risk performance. Some risk metrics can be associated with the financial concept of value at- risk, for instance, demand-value-at-risk and inventory value- at-risk (Sodhi, 2005). Thus, there is much modeling and empirical work to be explored in the area of supply chain risk management.
- One conclusion from this research study is that the impact of product design on supply chain performance has not been widely recognised – either in literature or in practice. The effect of design decisions on supply chains needs to be looked from a holistic, through-life perspective. In other words how will the design process itself,

i.e. the way that designs are created and specific design decisions, e.g. sourcing, choice of materials, physical characteristics, etc. impact supply chain responsiveness and costs from the launch of the product to its end of life.

- Many author provided useful insight about simulation. However, the development of a methodology that provides the procedures for the system designers for estimation of uncertainties for reliable results in simulation is not addressed.
- Different stages of SCRM process are mentioned by many authors. However, Interaction of different components of frameworks with each other in dynamic environment, such as design of early warning system that links to sources of risk and performance of chain is highly needed and is an opportunity for future research.

Limitations: The proposed framework is generalized in nature and can be applicable to any type of supply chain however; it is not validated on real industrial data.

Objective 2: Construction of framework for 3PL outsourcing processes with the help of representative literature review

- Contribution: Many articles were found that mentioned 3PLs outsourcing process. However, none of them presented a comprehensive framework as compared to the one in this research. Most of those frameworks were proposed in more generalized way and some of them were incomplete or dealt with some aspect of 3PLs process outsourcing only. To the best of our knowledge, this framework would be the first one in research that enlist all phases of 3PL outsourcing processes but also provide a step by step detail for supply chain and logistics managers along tools and approaches need to be adopted. The derived framework is validated partially using empirical data obtained from leading organizations in the region. These data is obtained through semi-structured interviews with two leading companies in Saudi Arabia engaged in a long term 3PL relationship.

  Main findings: In order to manage successful 3PL relationships, one must consider all aspects systematically and thoroughly. All these aspects and issues can be classified into 4 main phases. 3PL decision making phase, 3PL selection phase, 3PL contracting and 3PL relationship management phase.

Objective 3: To explore the applicability of newly released International Standard ISO 31000 "Risk Management – Principles and Guidelines" in 3PLs.

Contribution: To the best of our knowledge, the aforementioned framework is not implemented to 3PL context until now. A risk management process for 3PL is proposed taking into account all the phases of 3PL outsourcing framework developed in this thesis.

Main findings: Systematically identification of risks in all phases of 3PL outsourcing process is best approach for managing the effective relationship.

Various risks are identified based on the literature and through the case study conducted and methods and tools for risk identification and evaluation are proposed as well. Also, various risk treatment strategies reactive or proactive in nature are proposed.

Objective 4: To propose an idea of a model for 3PL relationship evaluation by using neural network.

Main findings:

This is achieved through following steps. Initially, important key performance indicators and metrics are identified through literature review and case study conducted. Furthermore, expected outputs impacting 3PL relationship are identified. Input and output measures can be used in a neural network to evaluate the relationship. The method takes some metrics/ input variables and then determines the level of relationship as an output. The general model has been outlined but was not fully developed due to lack of training data.

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APPENDICES

APPENDIX 1: BASICS DEFINITIONS

Risk – general definition: Risk means being exposed to the possibility of a bad outcome. Source: (Borge, 2001, p. 4).

Risk management: The process whereby decisions are made to accept a known or assessed risk and/or the implementation of actions to reduce the consequences or probability of occurrence. (Source: Risk: Analysis, Perception and Management, 1992, p. 5).

Supply chain: A set of relationships among suppliers, manufacturers, distributors, and retailers that facilitates the transformation of raw materials into final products. (Source: Beamon, 1998, p. 292).

Supply chain management: Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies. (Source: Council of supply chain management professionals).

Supply chain risk management: To, collaboratively with partners in a supply chain or on your own, apply risk management process tools to deal with risks and uncertainties caused by, or impacting on, logistics related activities or resources in the supply chain. (Source: Definition by the author in (Brindley (ed), 2004, p. 80), developed from (Norrman & Lindroth, 2002).

Logistics Management: Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverses flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements. (council of supply chain management professionals).

Outsourcing: In a typical supply chain, companies acquire raw materials, spare parts or components, products or services from suppliers locally or globally to achieve their objectives in turbulent business environment. This process is also known as outsourcing.

3PL: Similarly, when a company outsources all or some of its logistic functions to third party, the process is known as 3PL.

3PL Risk Management: To, collaboratively with partners in a supply chain or on your own, apply risk management process tools to deal with risks and uncertainties caused by, or impacting on, logistics related activities or resources in the supply chain.

(Source: Definition by the author in Brindley (ed), 2004, p. 80, developed from Norrman & Lindroth, 2002).

APPENDIX 2: 3PL QUESTIONNAIRE

Phase 1: Pre-Contracting Phase

1. How does company perform strategic analysis? Such as

- Types of services offered to customers
- Logistic outsourcing Strategy
- Types of relationships with customers
- Understanding of competiveness and profitability
- Customer requirement

2. Does your company provide consultation to customer regarding complete understanding of his in-house capabilities & resources?

Does your firm help companies to calculate their In-House logistic cost? What factors do you consider while determining the cost? How do you calculate total landed cost?

3. Do companies outsource all logistic functions or some of them? How does your firm help companies to determine about the functions that need to be outsourced?

1. How do you perform a comparison between In-House performance and expected outsourcing performance in terms?

2. What happen to buyer's employees when you control all of their logistic functions?
   Expected outcome:
   I. Remain in buyer's firm
   II. Taken by 3PL
   III. Fire

3. What are other factors you consider in this Phase?

4. Does a company follow any risk management plan?

1. Phase 2: Contracting
    1. What is the significance of a contract?

Expected Outcome:

Understanding of strategic importance of contract

Risk:

Over trust in supplier and showing less importance to contract

Spending too little time writing the contract and pretending that the partnership relationship with the vendor will take care of everything

2. What are different types of contracts used for 3PLs process

How to choose the best contract type

Expected Outcome:

Develop an incentive Contract with well defined performance reward and penalty clauses

Win-Win Contract

Risks :

Wrong contract selection

3. What are different elements that need to be considered in contract

Expected Outcome:

Preciseness, completeness, incentive based, Balanced, Flexible

Risks:

Ill-defined contract

4. How do you negotiate while contracting

Expected Outcome:

Risks:

proceedings and difficulty in contract negotiation

Spending too little time negotiating the contract and pretending that the partnership relationship with the vendor will take care of everything

5. How do you make sure that contract is written balanced and two sided

Expected Outcome:

Win-Win contract

Risks:

One sided Contract

Lack of a contingency plan for major disruptions at the service provider

6. How do you finalize about joint performance objectives and metrics to measure agreed to service level?

- Expected Outcome:
- Create Joint performance Objectives clearly

  Finalize metrics to measure agreed-to-service levels

  Risks
- Expectations of services are often difficult to specify, standardize and predict
- Difference of opinion or perception of service level of 3PL provider

7. How to introduce flexibility in contract

- Expected Outcome:
- an escape or contingency statement that allows either party to adjust for unexpected events
- Risks:
- Disputes due to inflexible contract
- Not putting a full communication plan into effect including escalation processes
- Initiating an agreement with a service provider that limits flexibility in the future
-

8. How to realize and understand hidden costs in contract? How can we observe them?

Expected Outcome:

Opportunism free contract

Risks:

- Vendors withhold or distort information to technically misinterpret contract, or to use dependence of outsourcers for price increase.
- Failure to realize hidden costs of contract

How do you determine different prices for service contracts

Expected Outcome:

Risks:

- The problems is concerned with the importance of people and their competence for service businesses, a competence that is difficult to specify in a contract.
- Expectations of services are often difficult to specify, standardize and predict

9. What are other factors you consider in this Phase?

Phase 3: 3PL Relationship Management

1. What are the implementation steps you have performed after signing contract?

Expected outcome:

Risks:

Problems in the Implementation of 3PL Arrangements

2. Do you perform inter-organizational planning? Such as demand forecasting or service scheduling. How?

3. How do you determine level of control/Power in both parties? Equal or one sided

4. How to make sure about shared risk and reward?

5. What are important KPIs indicated by your firm for performance assessment

_____How do you measure and evaluate performance

6. How to build effective performance monitoring system

7. What are different attributes of good relationship?

8. How do you evaluate relationships?
    a. Factor for Relationship Building management

- Trust:
    - What are the antecedents of trust

_____

    - How to assess and measure trust level

_____

    - How to build strong trust level

_____

- Interaction/communication/coordination:
    - What are the antecedents of strong interaction/communication and coordination?

_____

    - How to assess level of interaction/communication and coordination

_____

    - How to establish effective Interaction/communication/coordination system

_____

- Information Sharing
    - What are the antecedents of information sharing?

_____

    - How to assess and measure level of information sharing

_____

    - How to establish effective Interaction/communication/coordination system

_____

- Conflict Resolution Mechanism

- What are the antecedents of conflict resolution or disputes?

_____

- Conflicts between the partners and within each partner company undermining the effectiveness of the relationship

_____

- How to assess and measure the level of mechanism

_____

- How to build strong mechanism for disputes and conflicts?

_____

- Organizational culture
  - What are the antecedents of successful organizational culture?

_____

  - How to assess and measure level of culture

_____

  - How to build strong organizational culture

_____

❖ What are other 3PL Relationship Management success factors?

❖ What are the expected 3PL Outcomes?

APPENDIX 4: 3PL RELATIONSHIP EVALUATION QUESTIONNAIRE

Data collection/ questionnaire

5. For 3PL Relationship Evaluation/ performance between you and Supplier, what are the important elements or quantitative factors that enable you to measure or evaluate relationship.

   Are following elements being used for this purpose?

Table 34: questionaire for relationship evaluation attributes

1. operational efficiency I. **Shipment program accomplishment (SPA)**: Percentage of shipments carried out before the scheduled date. II. **Packing consumption efficiency (PCE):** Difference between the real consumption of packing and the product of the weight of the product packed and the consumption of packing per weight of product, as a percentage of the above mentioned product	
2. inventory accuracy I. **Internal storage inventory accuracy** (ISIA): Difference between the number of items of a certain product in internal storage and the number registered in the system, as a percentage of the former. II. **External storage inventory accuracy** (ESIA): Difference between the number of items of a certain product in external storage and the number registered in the system, as a percentage of the former	
3. internal operation product damage I. **Finished product packing sweeping (FPPS):** Percentage of products swept from the floor during the packing process, in relation to the total weight properly packed. II. Finished product internal storage sweeping (FPISS): Percentage of products swept from the floor in internal storage during	

moving and storing processes, in relation to the total weight properly shipped. III. **Finished product external storage sweeping (FPESS):** Percentage of products swept from the floor in external storage during moving and storing processes, in relation to the total weight properly shipped	
4. External operation product damage I. **Transportation damage (TD):** Percentage of products damaged during transportation, in relation to the total weight of products transported from the factory and from external storage. II. **Transportation accidents (TA):** Number of accidents occurred during transportation of finished products. III. **Cargo theft (CT):** Number of theft events during transportation of products	
5. distribution efficiency I. **Out-of-date-deliveries (ODD):** Percentage of deliveries executed after the agreed date. II. **External client complaints cost (ECC):** Cost associated to the uncertainty of out-of-specification deliveries, registered through client complaints. III. **External client satisfaction (ECS):** Result of an external survey indicating the client's perception of the level of service, in percentage.	
6. distribution costs I. Distribution/transfer transport cost (DTC): Percentage of transport expenses in relation to the net operating income	
7. moving and storage costs I. Internal storage moving and storing cost (ISMSC): Percentage of moving and storing (in internal storage) expenses in relation to the net operating income. II. External storage moving and storing cost (ESMSC):	

Percentage of moving and storing (in external storage) expenses in relation to the net operating income.	
8. information quality for planning I. **Shipment estimate precision (SEP):** Difference between the total weight of products programmed for shipment as defined by the resin company and the forecasted weight, expressed in percentage of the latter **demand variability** II. **Shipment tonnage coefficient of variation (STCV):** Standard deviation of the tonnage of products shipped in relation to the average, expressed in percentage. III. **Same day programmed shipments (SDPS):** Percentage of the total weight of shipments programmed to the same day in relation to the total weight of programmed shipments.	
9. Trust [How do you calculate trust level]	
10. Commitment [How do you calculate commitment level]	
11. Communication [How do you calculate communication level]	
12. Collaboration [How do you calculate collaboration level]	
13. Conflict resolution [How do you calculate conflict resolution level]	

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  King Fahd University of Petroleum & Minerals, Dhahran, KSA (Feb 2003 – June 2008)

  Subject: Bachelor of Science

  Major: Industrial Engineering

  Major GPA 3.01/4.0 [80%]

Work Experience

King Fahd University of Petroleum & Minerals, Dhahran KSA Oct 2008 – To date

Research Assistant

- Pursuing Master Degree in Industrial Engineering by conducting Research & Study
- Departmental Administrative works, teaching & grading Undergraduate students

SAAD Group of Companies Al-Khobar, KSA, June 2007-Jan 2008

Worked as COOP Trainee

- Preventive Maintenance analysis
- Design of Facility planning & Layout at wood Factory
- Safety & Health Programs Management
- Design of Strategic Planning & Balance Scorecard
- Lean Manufacturing & Forecasting Operations

Other Skills and Achievements

- **Member of IIE(Institute of Industrial Engineers) Student chapter**

  Roles & Responsibility:

  Actively take part in activities conducted by student forum at KFUPM such as presenting latest updates on IIE to student get together.

- **Voluntary Member of Educational & Finance Committees of primary educational institutions**

  Roles & Responsibility:

  Teach young students Basic English, Math and ethics voluntarily

  Perform financial audit of organizations and prepare reports on expenditure, income, salaries and profit & loss etc.

Technical Skills & Hobbies

- Surfing Creativity tools for critical thinking and problem solving
- Surfing and web browsing Tools for understanding complex situations.
- Surfing and reading literature on Techniques for effective decision making.
- Familiar with Project planning skills
- Completely familiar with Basic finance tools and able to understand and analyze financial information, decision making for profitability etc.
- Completely familiar with Project management tools.
- Excellent skills in performing statistical analysis on business problems and able to use Statistical Software's for optimization & Modeling such as

  TORA (very good), LINGO(very good), LINDO(very good) and GAMS(good), Mini Tab(Excellent), MATLAB (good), Arena((very good), MS Office(excellent)
- Fully conversant with the operation, installation and troubleshooting of computers
- Surfing Career counseling, Personal growth, Time Management, Leadership & creativity development.
- Playing Judo & Taekwondo(team player)

Languages

English, Arabic & Urdu